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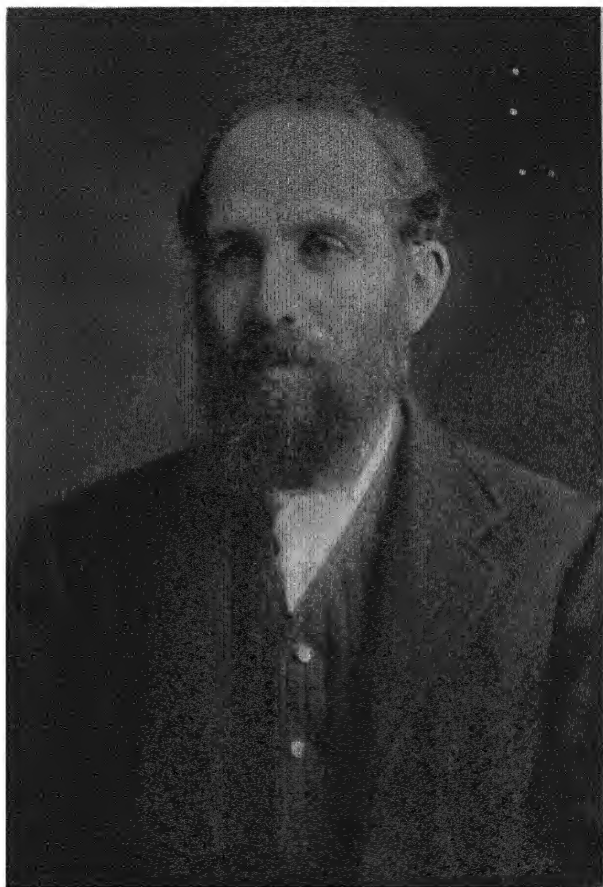


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BIOGRAPHICAL FRAGMENTS

BY

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TO MY WIFE

WHO DID SO MUCH TO SMOOTH THE PATH OF
MY ACTIVE LIFE AND WHOSE PATIENCE
AND DEVOTION HAVE NEVER FAILED
ME IN LATER YEARS

PREFACE

My chief object in these reminiscences is to preserve some impressions of times and places in which my friends have expressed an interest, and of the personality of some scientific men of a past generation. I have never had any inclination to publish an autobiography and my advancing age and ill-health have made it impossible for me to add several chapters which at one time I had in view.

A detailed record of the work of the 25 years during which I was a Professor in Manchester was published by my old students in 1906.* I have attempted to indicate the incomplete character of this book by the title I have chosen.

The chapter on 'Potential Matter—A Holiday Dream' and the 'Biographical Byways' were originally published in *Nature*, and I have to thank the Editor of that Journal for permission to re-issue them in their present form. The opportunity has been taken to make a few minor alterations in the 'Biographical Byways'.

I must express sincere gratitude to my wife for a vast amount of help in the editing of the manuscript and to Sir Philip Hartog for kindly undertaking

* *The Physical Laboratories of the University of Manchester* (Manchester University Press).

the work of preparing the book for publication, in which his experience has been invaluable.

I am also indebted to members of the Siamese Legation who kindly translated the address on page 100, and to Dr. Lionel Barnett, Mrs. Rhys Davids, Sir Frank Dyson, Mr. Lionel de Rothschild, Sir Napier Shaw, Dr. G. C. Simpson, and Sir Francis Younghusband for the verification of certain points of detail.

ARTHUR SCHUSTER.

July, 1932.

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I tender my thanks for permission to use the photographs from which Illustrations I and VIII were made to Messrs. Lafayette and Warwick Brookes respectively and to the Manchester Geographical Society for the block used for Illustration II (the map). The remaining illustrations are reproduced from photographs taken by my wife during a journey we made together in 1908 over the same ground as that described in pp. 102-168, but in the opposite direction.

PERSONAL RECOLLECTIONS AND
EXPERIENCES

I. PARENTAGE

A USEFUL genealogical record of Jewish families connected with Frankfort-on-Main has been published by Dr. Alexander Dietz under the title of *Stammbuch der Frankfurter Juden*, a work based on the information supplied by the inscriptions on the grave-stones in Jewish cemeteries, and relevant documents.

Before the beginning of the nineteenth century Jews were almost universally known by their first or 'given' names, supplemented for better identification by some attribute or sobriquet associated with the locality of their birth, their occupation, or the name of the house in which they lived. Such attributes often subsequently became the family name.

The origin of the name 'Schuster' is not known. It is sometimes said to be derived from the old town of Shuster in Persia.

So far as the records go, the family was originally called Etingen or Ettingen, a corruption of Oettingen, which is a small town in Bavaria, about twenty-five miles south of Ansbach. The first progenitor who can be traced is one Elias Etingen 'in the house of the wild man', who settled in Frankfort in the year 1607. He was soon followed by others with residential qualifications such as 'the narrow

door', 'the warm bath', and 'the silver candlestick'. In the seventeenth century the name Schuster was more and more generally adopted.

Dr. Dietz occasionally gives some information on the activities of the persons concerned. Thus I find that, in 1748, one Moses Max Schuster was employed by the Prince of Thurn and Taxis, who then held the monopoly of the postal service in Germany. This member of the family is said to have been a noted chess-player. Another member, Jacob Etingen Schuster, who died in 1696, is described as 'the man of rich knowledge, whose name is known everywhere'.

The present members of the family are descendants of one Juda Joseph 'of the white lily'. He started a business in cotton goods in the middle of the eighteenth century under the name of Schuster Brothers, trading principally with England. On his death in 1782 the business was continued by his son, Samuel Juda.

When Napoleon occupied Frankfort in 1808 he confiscated all the property of the family because they traded in English goods. As a consequence, my grandfather, Joseph Samuel (1785-1858), and his brothers decided to start business in England. Two of them, Leo and Samuel, settled in this country about 1811, while my grandfather, who was the eldest brother, remained in Frankfort, carrying on the business there as a branch of the English firm. I can remember him chiefly from the fact that he taught me to read the clock.

When Leo came to England, after a short stay in London, he wrote to acquaint his brothers of his discovery that the centre of the cotton trade was not

in London but in Manchester. There he went without delay to organize the business. Before long he returned to London, where he remained permanently and acquired a position of some influence, becoming the first chairman of the London and Brighton Railway.

The youngest brother, Henry, settled in Brussels, presumably in order to look after the transit of goods. His only son, Louis, came to England at an early age and married a member of the Birley family in Manchester.

My own father, Francis Joseph, was born in 1823, and at the conclusion of his school education entered the family business and did some travelling on its behalf. He used to recount to us his experiences on his journeys to the great fairs of Leipzig and on his frequent visits to England, as when on one occasion he was laughed at by a little British-born cousin because he had cut his breakfast toast with a knife, instead of breaking it with his fingers. The incident rankled.

Though he became skilled in distinguishing between different kinds of cotton and woollen goods, my father's commercial ambitions found a more congenial field when, taking the husband of his only sister into partnership, he founded a very successful banking firm in Frankfort under the name of Schuster Brothers. He soon acquired an important position in the commercial life of the city, was made a director of the municipal bank, and was often consulted on financial matters. During the political troubles of 1848 he joined the Cavalry Volunteer Corps, formed to protect the town against possible

revolutionary outbreaks. I remember his old-fashioned pistols, which he kept as a memento, and, with less interest or pleasure, the flute on which he occasionally played.

In his private life my father was of a nervous temperament and apt to look at the dark side of things. Small peccadilloes on the part of his children or dependants were often magnified into major offences. I once got into serious trouble through having my hair cut by a barber who did not happen to be in favour at the time.

I was born on the 12th September 1851 and was about seven years old when our home life was greatly affected by the illness which befell my mother. Medical science was not sufficiently advanced at the time to diagnose the disease. Believed to be suffering from a purely nervous ailment, she was sent to various health resorts, without favourable results. A few years later glaucoma set in, and one eye was removed in the hope of saving the other. But the disease relentlessly took its course, and during the last thirty-five or forty years of her life she was totally blind. The illness is now well known under the name of Graves' disease or exophthalmic goitre, and is curable in its early stages. It is sad to think how much suffering she might have been spared, but, like many of the blind, she bore her fate with fortitude. Her greatest joy was to have her small grandchildren brought to her bedside, so that she could feel their faces. She had also a remarkable power of entering into mental contact with those she loved. One morning I opened the door of her room, but seeing that she was suffering from one of her attacks

of pain I silently withdrew without a word being said. During the afternoon I entered her room again, and she said, 'When you came in this morning, I felt as if you had some bad news to give me'. It was true; a nephew of hers had died in Germany after a few days of illness and I had been charged to inform her of the loss.

I have only one vivid recollection of my mother in full vigour of health. I can see her in my mind's eye standing upright and looking out of the window, dressed in a material marked in coloured stripes like a tartan. Many years later I described the dress to her and she confirmed my recollection that she possessed such a dress at the time.

II. EARLY RECOLLECTIONS

SOME thirty or forty years ago I committed to paper an account of my early school life. In this document, which I have preserved, I insist on the efforts I made to be allowed to be sent to school at the same time as my elder brother. The difficulty was that I still wore
Aet. 5 petticoats; but when I found out that there was already a boy who went to school in such garments, I surreptitiously put together the various requirements, such as a slate and pencils, and one morning actually started on my way. I was of course not allowed to proceed far, and had to wait another six months, till I was five and a half years old. I then had to pass an examination to determine the form in which I was to be placed. It consisted in my having to write down on my slate *Der Himmel ist blau*, which I did successfully, though I felt much ashamed at not being able to keep a straight line, my pencil rambling along the best part of a quadrant.

I have to add that the episode of the petticoats, which, though it was clearly in my memory when recorded in the manuscript referred to above, has since entirely passed out of my mental vision.

A further incident of these early days is worth re-

cordova, as it gives the first evidence I can adduce of a scientific leaning.

Aet. 6

One day I was told that, in a particular form of the school, boys were shown how to make magnets, and I became interested, because I had been playing about at home with toy figures of aquatic animals, which were moved through the water by a magnet acting on short pieces of iron inserted into their mouths. Hence my desire to know more about magnets.

The class-rooms of the school were on the ground floor, with window-sills sufficiently low for boys outside to pull themselves up until they could see what was going on inside the room. Though I remember accomplishing the necessary gymnastic exercise to get a peep through the window, I cannot recollect any results. There probably were none beyond a scolding.

The school was a private enterprise under the management of two masters, Messrs. Hassel and Ruoff, and mainly intended for boys destined to pursue a commercial career. The first few years of my scholastic experience were uneventful; I kept at, or near, the top of my class, arithmetic and modern languages giving me no trouble. I was fairly happy, both at home and at school. Unfortunately this state of quiet satisfaction was rudely interrupted by events which introduced a period of intense mental distress.

It befell in this way. In the autumn of the year 1861, when I was ten years old, I was taken ill with an attack of whooping-cough, made a slow recovery, and missed a large part of the winter's work. The scholastic year ended at Easter, when the deserving boys were moved up from one form to the next

Aet. 10

higher one. The school authorities were prepared to promote me, in spite of the loss of time through non-attendance, but my parents preferred to keep me back so as to give me an easier time. I resented this most strongly, and when at the final ceremony of the year it was announced to the assembled school that, at the wish of my parents, I was not promoted to a higher class, I broke down. Possessed by what would now be called a complex, I lost control of myself and reached middle age before I could recall those days without a shudder. Fortunately I was removed from this school in the following spring.

Act. 11

As a boy I often heard my father say that his sons could choose their own profession, though he strongly advised against that of a soldier or a medical man. I have nevertheless a feeling, confirmed by subsequent events, that he did not seriously contemplate the possibility of our breaking away from the family tradition of following a commercial career. He himself had started a flourishing banking firm at Frankfort, and inherited a share in the Manchester business, with its branches in London, Bradford and Rio de Janeiro. He took it for granted that we should choose the natural course, which was to enter the open gates. But whatever his ideas were of our ultimate destination, my father had a strong belief in a wide and general education. In order to provide for all contingencies he decided to let his sons complete their school education in the Gymnasium, the only school in Frankfort which prepared boys for entry into one of the German universities; and, to bring us up to the proper standard, he engaged a private tutor, Dr. Harold Schütz, about whom more will be

said. Dr. Schütz resided with us, having a small room to himself in our house in the Taunus Anlage, took us out for our daily walk, and sometimes farther afield for excursions into the country. I have no record, but I imagine it must have been towards the spring of 1862 that Dr. Schütz took his place as a member of the family.

III. THE FRANKFORT GYMNASIUM

Aet. 12 THE forms of the Gymnasium were numbered, beginning with *septima*. There was an *unter-quarta* and an *ober-quarta* and each boy was kept normally two years in both *secunda* and *prima*, so that the whole school life extended over eleven years. There was an important break on entering *secunda*. Up to that point, boys were addressed as *Du*, but were then promoted to the more formal *Sie*. The average age on entering *septima* was about eight years. I had been prepared by our tutor for entry into *quinta*, and had to pass an examination to show my fitness for it. Latin was the only subject in which we were examined; we were asked to translate into Latin a few German sentences written up on the black-board.

There were three other boys trying for the same form; one of them, about thirty years later, married a cousin of mine, and another became a successful barrister. The latter got through his translation without any error, I had four mistakes in mine and the two others were, I believe, below the standard. After the results were announced, the form-master who had conducted the examination complimented me, not so much, as he said, on the knowledge I had

shown, but on the fact, which he said he had specially noted, that I had worked steadily for myself without troubling about what my neighbours were doing. I felt a little ashamed of myself, because I had actually copied one sentence from my neighbour. As an excuse for what may be looked upon as a dishonest act, I may mention that many years later Lord Kelvin used to relate that in his Cambridge days it was not looked upon as dishonest to cheat in a non-competitive examination.

I spent five years at the Gymnasium and the remembrance of that period is still dominated by the unhappy experiences of my early school life, which continued to provoke a discontented and even rebellious attitude, and often got me into trouble both at home and in school. A better spirit might have been introduced had the headmaster, Classen by name—a sensible and tactful man—not been called away to a more remunerative post in Hamburg at the end of my first year. His successor, Tycho Mommсен, brother of the historian, whose strident voice was a characteristic symbol of his harsh and irritating personality, was generally unpopular. I look back with satisfaction to an encounter in which he threatened me with expulsion. He ultimately got the worst of it, but the story is too long to be told here.

The teachers were a capable but uninspiring set of men, not always able to keep proper discipline in the class-room.

There were some curious specimens among them. The form-master of *ober-quarta* was an elderly gentleman who took snuff copiously. When the class

showed impatience by their favourite method of scraping feet on the floor, he appealed to their generosity, and when this had not the desired effect, called out with a sigh, 'This is another nail in my coffin'. The class responded by making a record of the number of nails they could insert in the hour. I am afraid I was rather a leader in these displays, but ultimately took pity on him, which he later generously acknowledged. My pet aversion was one of the teachers of Greek, who resented any disturbance on the ground that it was disrespectful to the classical authors we were reading. He was said to have gained a reputation by a dissertation on the question whether the threshold of Odysseus was made of stone or wood, and was much concerned with a passage in Xenophon containing a list of the ships sent by various townships to form a fleet for war purposes. The total was also mentioned and differed by one unit from the sum of the individual entries. We had to listen to a serious discussion as to whether the discrepancy was due to an error of arithmetic or a mistake in the original list.

The teacher of mathematics, Oppel, was an oddity, with a leaning towards omniscience. He could be made to discuss any subject in class by raising a question about it. Once he spent much time in arguing as to whether a man without an umbrella, surprised by rain when at a distance from home, would get wetter if he walked or ran home. Running would take a shorter time, but the inclination of his body would expose a larger surface.

Such small amount of science as was given was confined to elementary mechanics taught in *secunda*.

I cannot conclude this survey of the teaching staff without mentioning the singing master, Maus. Attendance at the singing lessons was compulsory, except by special permission of the master, only granted on the ground of incapacity. I repeatedly applied for such permission, but the master insisted that I had quite 'a good little voice'; he could not, however, force me to sing. The lessons consisted in practising choral singing. I opened and shut my mouth without producing any sound, and as this did not help I tried the other way, and joined the chorus to the worst of my ability. 'Who sings so much out of tune?' asked the master. I suggested that I might be the culprit. 'Sing again', he demanded. I did so, with the result that I was excused from further attendance. The master got his revenge by detaining me in school for an hour, which was one of the recognized forms of punishment.

I do not wish to condemn the school as inefficient. Though some of the teachers were certainly stale, it no doubt fulfilled its object, which was to prepare boys for the school-leaving, *i.e.* *Abiturienten* Certificate. Its curriculum had good points. Among them was the importance attached to the German language and literature, which included the learning of poetry by heart and the writing of essays. This being the only part of the work that really interested me, I give an abbreviated list of the subjects on which we were asked to express our views in the form of an essay.

1. Advantages and Disadvantages of Town and Country Life.
2. Life compared with a Sea-voyage.

3. The Poetry of Flowers.
4. A Journey to the Lahn.
5. Dreams.
6. The Last Days of Marcellus.
7. The Choice of a Profession.
8. *Perspectis omnibus operibus, quae ingenio humano constant mirari occurrit nihil paene non igni perfici.*
9. What does History call a *Great Man*?
10. The Human Relations and Interests that enter into Goethe's *Novelle*.
11. Eulogy of Great Geographical Explorers.
12. Shakespeare's *Coriolanus* as an Example of Tragedy.

After a subject had been given out in class, a month was allowed for the work, and during that time we were free to converse with each other about it. The essays were then collected, and criticized by the master in charge. Reference books were available, including an excellent translation of Shakespeare's plays, required for dealing with the last item.

I have fortunately preserved my own manuscripts. That on the choice of a profession possesses some biographical interest and I have, for this reason, reproduced it in an English translation.

DEAR FRIEND,

You cannot complain that I have left your letter too long without an answer. I write to you as quickly as I possibly can to assure you that I did not need the incentive of your communication to induce me to reflect on the choice of my future profession. My mind was already made up before receiving it. I have, after much deliberation, decided upon architecture. Although the decision I have taken has only lately become definite, you need not think that the idea itself is new and for that reason transitory. Even as a small

child I wished to devote myself to this profession, and I always prided myself on the fact that I did not, like other friends of mine, alter my choice every minute, though later, when I began to think more clearly, I wavered a little, but I never decided in favour of anything else. How old I was when the idea first came to me, I do not know; the earliest recollection that I have in this connexion goes back to my eighth year, the first in which I went to school, when I threatened a teacher who wanted to do something that did not please me, by saying to him that I would not build him a nice house later on. It is natural that at that time I was influenced by reasons quite different from the present ones, and, as I believe that it will interest you, I will explain them to you. To the child, that thing seems most beautiful and important which is most striking. Hence he plays with dolls which represent men and with everything that is later in life associated with man. It is my belief that one can get to know completely the character of a man from the games of his childhood. I, for my part, considered that houses and great buildings were the greatest masterpieces of men, and I always liked best to play with building blocks. Again, what do you think is the thing that most impresses a man who has lived always in the wilds, and is suddenly set down in a great town? I think that he looks first at the houses and churches before turning his eye on the carriages and vehicles driving past, or on the clock in the church tower. At the time, I lived in a neighbourhood that only within recent years has grown to be a great suburb of the town. I had therefore ample opportunity to observe houses in course of construction from their first foundations. The inclination to draw (I actually believed that drawing was the only thing needed for architecture) I always possessed. I attribute this mainly to the fact that I first learned to draw at home. The exercises, though they were composed only of a few straight lines, nevertheless represented something. When I went to school I was therefore already given somewhat more difficult exercises—difficult, naturally, in comparison with those of my

comrades. Had I, like them, been first obliged to draw a whole page, or several pages, full of parallel straight lines, I do not think I should ever have got beyond the most simple exercises. Mathematics, I thought, one did not need in this profession. However, for this subject I also acquired an inclination, as I advanced further into it. The principal reasons which influenced me to become an architect I can best make clear to you by writing down fully the trend of my thoughts. Only for a short time did I deliberate whether I would pursue business or learn a profession; but I considered longer as to what sort of a profession it was to be. In spite of the fact that, as you know, I have already been some years at the Gymnasium, I have never had any special inclination for study. The reason for this I do not know; it has, maybe, some connexion with the idea of a scholar that I early formed in my mind. I regarded him as a man who does nothing but sit behind his books and has no pleasure at all except from his books. Although for a long time I have recognized that this description is incorrect, I nevertheless believe that its early conception unconsciously influenced my choice. On the question of becoming a man of business I deliberated for some time, no doubt because it is my father's occupation. I renounced this vocation less for special reasons than out of preference for that of architect. I now ceased to consider anything else apart from that of a technical profession, and in this connexion I wavered between becoming a civil engineer, a mechanical engineer and an architect. The pursuits of the architect and of the civil engineer border so closely on one another that they sometimes overlap, so that the choice between them depends on minor considerations. Thus, after long deliberation, my choice likewise was determined by two points, in themselves of no great significance. The one was adherence to my early choice, the other consisted in the fact that the undertakings of the civil engineer for the most part extend over a long period, frequently several years, and I have a liking, when a task has been once begun, to finish it as quickly as possible. My reasons for not wishing

to become a mechanical engineer are chiefly as follows. I know that you have chosen this for your future profession and I will therefore go into the question somewhat closely. If I were to ask you what actually is the business of the mechanical engineer, you would answer that he either designs new machines or fulfils orders for those already invented. What purpose do these machines serve? After some little thought you would answer: 'Many different purposes'. It is, however, this variety of application which leads me to renounce the vocation. First you receive a commission to construct a threshing or sowing machine, and are serving the agriculturalist. Next some manufacturer asks for a machine and you are in the service of the factory-owner. Then you construct an engine for a steamship and you serve those who voyage by sea. Before long you apply yourself to the service of the travelling public in the production of a locomotive. I know well that it is just this variety which is attractive to many. However, I must insist that I myself find no pleasure in it. You will protest against my calling, that it has too little variety. Now, although the business of the architect is always concerned with the building of houses, except in such cases as when he branches off into bridge-building, etc., I nevertheless know of no profession possessed of more variety than one which ever affords increasing opportunity of creating something new, nor of a calling in which one has more freedom to act according to one's judgment. For your part you construct machines on which you are in many respects dependent. There are frequently machines whose execution is possible only in one way; often among many methods of execution only one is practicable. You are unable to have any regard for beauty. How different with my calling! Taste is one of the chief qualities to be possessed by the architect and a very great deal I am able to carry out entirely according to my own judgment. I write this to you, not from disapproval of your own choice, but in order to show you that I cannot gratify your wish that I should devote myself to the same profession as you. I believe, however, that

even so, we can to some extent share our studies. There is, however, still plenty of time to talk of this when we meet.

Until then, *Lebewohl!* ..

Your friend

ARTHIUR SCHUSTER

(*Note.*—The above translation follows the German original as far as possible, but it is sometimes difficult to find expressions in different languages that are complete equivalents.)

The remark recorded in my essay that ‘taste is one of the chief qualities to be possessed by the architect’ invites an addition. Close to the dwelling in which part of my childhood was passed, there was a house built in a blatant Gothic style, which, as recollection tells me, I admired, but which I now wish to disclaim as a witness to good taste. Fortunately the house is pulled down, but it remains in my memory because I was taken out of bed to see the great comet of Donati in 1858, which hung right over it.

The Gymnasium was housed in an old monastery, a dark and dingy building in the Prediger-Strasse, near the Cathedral, and about a mile from our home in the Taunus Anlage. Lessons began at seven o’clock in summer and eight in winter. There was an interval of two hours for dinner in the middle of the day, and lessons ended at four or five o’clock, according to the season. A certain amount of homework had to be done in the evening. This was followed by a light supper and bed at nine o’clock. On Wednesday and Saturday the afternoons were free.

The school possessed an excellent playground, available for games, and two hours a week were set aside for regular gymnastic training. In the school

reports, which were sent to the parents twice a year, efficiency in gymnastics was entered as taking equal rank with other subjects. The teacher was a young man who could jump his own height.

Instruction was also given in recognized games, such as a kind of cricket and rounders. The former was called *Thor-Ball* (gate-ball). Its essential equipment consisted of three vertical bars, about eighteen inches high, connected together, and serving as a wicket. The openings between the bars gave it roughly the shape of a gate, and the bowler's aim was to upset the structure bodily.

Other forms of exercise were also encouraged, swimming in summer and skating in winter being compulsory.

The way to and from school was sometimes enlivened by indulgence in rather vulgar schoolboy pranks. Ringing the bell of a house and running away was a common form of such amusement. The residence of the French Ambassador¹ offered a favourite field of action, because the butler, though lying in wait, was too stout to catch us.

A more ambitious entertainment was offered by the circumstance that the father of one of the boys was a druggist, who could supply the material for coloured flames, such as are used in the so-called Bengal lights of ordinary fireworks. On several successive nights we anticipated the recent fashion of flood-lighting by producing a very effective illumination of some of the principal monuments in the town, but when the newspapers took notice of us the police interfered.

¹See p. 29, below.

On the 6th December in each year the monotony of school routine was interrupted by the traditional celebration of the feast of St. Nicholas, the school-boys' patron saint. The ritual no doubt varied in different places, but in the Frankfort Gymnasium it was customary for a few boys in the same form to robe themselves in some simple disguise, and with masked faces to invade the home of one of their masters. Some would carry birch-rods, others a supply of a peculiar cake (*Lebkuchen*) cut up into slices of grotesque shape. There followed the semblance of a fight, in which the birch-rods served as weapons. Peace was declared when the master showed, by calling out the names of his invaders, that he had penetrated their disguise, and a bottle of wine appeared on the table. Curiously enough to be selected as the victim of this playful ceremony was looked upon as a sign of popularity.

On the speech-day, on which the annual prizes were awarded, the scholars assembled in the Kaiser-Saal of the Römer, which is the Town-hall, and the most famous building of the city. From our seats our eyes could wander along the walls of the spacious room, with its life-size portraits of the successive Emperors, beginning with Charlemagne. By a curious coincidence, the Holy Roman Empire was brought to an end by the resignation of Francis II, just as the walls of the hall were completely covered.

Before leaving the account of school experiences, it may be worth recording that it was two of my fellow pupils for whose benefit that immortal work *Struwwelpeter* was written. Unfortunately I cannot

boast of their personal acquaintance, as, being older, they sat in higher forms. The writer was the Medical Superintendent of an Asylum for the Insane, called Heinrich Hoffmann, and I understand that he both wrote the verses and drew the illustrations.

IV. DR. HAROLD SCHÜTZ

THE tutor who, as already mentioned, was engaged by my father to prepare my brothers and myself for entry into the Gymnasium, remained a member of the household during the whole of our school career. His duty was to act *in loco parentis* in all educational matters. A Westphalian by birth, he escaped the Prussian military service on account of abnormal shortsightedness. In many ways a remarkable man, he interpreted his duties liberally. One of his first acts was to improvise a horizontal bar, utilizing as supports the jambs of the door connecting our bedroom and study. He next persuaded my father to buy a lathe, on which I received my first lesson in handicraft, and I got as far as making a set of chess-men.

One Christmas evening I found, beneath the lighted tree, an electric frictional plate-machine. It was of an old-fashioned construction, which I suppose boys would not look at now, but I spent some happy hours playing with Leyden jars and Lichtenberg's figures; but such amusements had to be reserved for holidays. In term-time I was otherwise occupied, which suited Dr. Schütz very well, as he was preparing a dissertation on a problem in the theory of numbers for submission to the University

of Göttingen, where he had completed his studies before coming to us.

After leaving school I was at a loose end for about nine months, when he had the opportunity of pushing me on a bit in mathematics, especially in differential calculus. His methods were original, but as I had no examination in prospect this may have been an advantage.

Act. 16

He was fond of numerical examples, such as the determination of π to a large number of decimal places, or the calculation of logarithms to an arbitrarily given base. Odd problems attracted him and he showed me how to deal with Diophantine equations, which are concerned with problems in which the numerical solution must necessarily be an integral number. One example he gave was that of a man who had bought some bottles of Rhine wine and some of Moselle. He had forgotten how many of each kind, only remembering the prices and the total expense. Being a mathematician, this was sufficient to enable him to calculate the missing numbers.

I am grateful to Harold Schutz for his instruction, which was always sound and sometimes inspiring, even opening out the vista of a time when I might hope to make a name for myself in the way of scientific discovery. He had one great fault, and this severely affected the feeling of gratitude, which was not always as conspicuous on my part as it should have been. He never would admit his ignorance of any subject, even when it was pretty obvious. One example, which long affected my feeling towards him, will suffice.

One evening I was sitting under an oil-lamp holding up a small object against the illuminated lamp-

shade. I saw a double image of the object, no doubt due to double astigmatism, a defect only diagnosed many years later. I shut one eye, but the double image remained. As soon as I had an opportunity, I asked Dr. Schütz to explain this. 'You have two eyes', he said, 'and each will give you an image'. 'But one of them was shut', I objected. Yet nothing would move him. He persisted that I must have opened the other eye without knowing it.

Schütz made friends easily and was keen to take part in the intellectual life of the city. We consequently found ourselves sometimes accompanied on our walks by new acquaintances. Among these I recall with special pleasure Ernst Abbe, who subsequently gained world-wide fame as optical adviser to the firm of Zeiss. At the time of which I am writing, he was engaged by the town of Frankfort to regulate the clocks of the town. He used for this purpose a small transit instrument set up on the tower of the church of St. Paul. I was much flattered by his invitation one morning to look at the star Sirius, passing across the wires of his instrument, but unfortunately I could not get the star into focus owing to my astigmatism. A less flattering occasion was on a walk when he was discussing a scientific problem with Dr. Schütz, and was interrupted by some question of mine. Abbe suggested corporal punishment to keep me quiet! This incident was forgiven when I found that he remembered our acquaintance many years later on a visit to London.

Schütz ultimately became headmaster of a popular school in Southern Bavaria. He was a worthy man who will not easily be forgotten.

V. FRANKFORT-ON-MAIN AND THE SEVEN WEEKS' WAR

IN the days of my childhood one quarter of the population of Frankfort were Jews, who possessed no civil rights until 1864, when a ballot of citizens was taken which conferred on them the power of voting at municipal elections. Napoleon the First, under the influence of the Rothschild family, had helped to mitigate Jewish disabilities by abolishing the Ghetto, as the quarter of the town was called into which all Jews had to retire before 10 o'clock in the evening. There still remained, however, among the population a strong antipathy to the Semitic race, and boys of Jewish appearance were accustomed to having opprobrious names flung at them in the streets. My father remembered a poster exposed in front of a beer-garden in Offenbach, a small town near Frankfort, which bore the inscription:

'Ein Jud' und ein Schwein
Darf hier nicht herein.'¹

In spite of their persecution, the Jews always remained loyal to their adopted country. After the downfall of Napoleon at the Battle of Leipzig, the

¹ Jews and pigs not admitted.

town of Frankfort celebrated the event by an illumination, when a learned and pious bookseller, who had adopted the name of Baer, exhibited a placard with the legend:

‘Napoleon hatte die grösste Macht;
An Chaum Baer hat niemand gedacht,
Napoleon ist kein Kaiser mehr;
Ich bin noch immer Chaum Baer.’¹

Quite apart from the Jewish element, the town of Frankfort always had something international in its tendencies and leanings. To this the Huguenot settlements in the neighbourhood largely contributed.

Within my recollection, there was a small town, Friedrichsdorf, in the Taunus mountains, where French was the current language, even in the schools. In Frankfort itself some of the most influential citizens bore names obviously of French origin, like de Neufville, de Bary and Gontard. In the church maintained by them, divine service was held in French, and Calvinistic doctrines were preached.

For the many French words used in the common language of the streets of Frankfort, the soldiery who over-ran the country in Napoleonic times were no doubt responsible.

An advocate of reciprocity will look similarly for words of modern German origin in the French vocabulary. He will find very few. One of them has an odd pedigree. The word in question is *vasistas*. As to its origin, the story goes that a German soldier,

¹This may be rendered:

‘Napoleon glory had and fame,
Of Chaum Baer none knew the name.
The Emperor’s no longer there,
But here am I, still Chaum Baer.’

finding himself in France, either as prisoner or victor, and noticing a small window of peculiar shape, asked *Was 'ist das?* (What is that?), and his French companions are supposed to have adopted this word as applied to that particular form of window. In the *International French and English Dictionary* the word *vasistas* is given as equivalent to *casement*.

When the Holy Roman Empire had come to an end in 1806 it was decided that Germany should in future consist of a confederation of sovereign states, and a new constitution based on this principle was formulated and embodied in the Final Act of the Congress of Vienna (9th June 1815).¹ Frankfort was declared to be the seat of the Diet of this federation, the meetings of the representatives of the federated states taking place within its walls. The regulations of the Diet ensuring a proper balance between the voting power and the importance of nearly forty states were necessarily complicated, but worked without serious breakdown during the fifty years of its existence.

All foreign states had permanent representatives residing in Frankfort. I have already referred to the French Ambassador. I sit daily in an armchair which belonged to the British representative, and was subsequently bought by my grandfather at an auction of the Ambassador's effects, when he retired from the position.

By the constitution of the Diet, the representative of Austria took the chair at its meetings, and this was a source of irritation to Prussia. When Bismarck

¹*Nouveau Recueil de Traité d'Alliance*, etc., by G. F. de Martens, vol. ii, pp. 379-471.

was sent to Frankfort in 1851 as Prussian representative, and took a cigar out of his pocket during the first meeting he attended, he was stopped and told that the Chairman was the only person allowed to smoke. Bismarck gave in at the time, but brought a whole box of cigars to the next meeting, and this he handed round the assembly before the officials had time to interfere. But I must pass to more serious matters.

Aet. 15 The war of 1866 was a war between Prussia and Austria for supremacy in Germany. Ostensibly it arose out of the failure of the negotiations subsequent to the successful campaign of the joint forces of Prussia and Austria against Denmark; but, as Bismarck had said in a memorable speech, the great questions of the day concerning Germany could not be decided by talking, but only by blood and iron.

As soon as the threat of war arose, the town of Frankfort declared its neutrality; but there is no doubt that its sympathies were almost unanimously with Austria and the other German states which were opposing Prussia. Among my schoolfellows I can only recall one who sided with Prussia, and he was a descendant of one of the generals in the Napoleonic wars.

In what follows I propose to give an account of events that came within my own knowledge, or that can be substantiated and possibly amplified by books in my possession.¹

In allowing free scope to the flow of my recollec-

¹ (a) R. Schwemer, *Geschichte der freien Stadt Frankfurt-a-M.*, 3 vols.; (b) *Actenstücke zur neuesten Geschichte von Frankfurt-am-Main*. Published by Schweizerhard in Stuttgart.

tions of those exciting times, one reminiscent image stands out prominently. It is the entry into Frankfort of the Prussian army as a conquering force. In my mind I see my father and myself, together with a gentleman whom I cannot identify, standing outside the iron railings of our house in the Taunus Anlage, watching the passage of a regiment of cavalry. My father, who was something of a judge of horses, and had served in the cavalry during the revolution of 1848, commented on the fact that the men we saw had a more soldier-like bearing than their opponents.

Later on the same day, a man in officer's uniform knocked at the door, and declaring that he was a Prussian army doctor, demanded board and lodging. He was a brute.

According to Schwemer (vol. iii. (2) p. 315) it was at 6 o'clock in the evening on the 16th July that ten Westphalian hussars entered the town, and a larger contingent of cuirassiers followed soon after seven. This may be taken to confirm the trustworthiness of my recollection.

During the week or fortnight that the army doctor stayed in our house as an unwelcome guest, he lived on the fat of the land, and in return made himself as offensive as possible. He was fond of alluding to what he called 'blue beans', meaning rifle bullets, and on one occasion went so far as to declare, during dinner, that the whole of Frankfort would have to be reduced to beggary. But this was the end of him. Dr. Schütz, who as a Prussian had divided sympathies, reminded him privately that he had forced himself upon us without proper military authority, and might get into trouble if this were re-

ported. He packed up his belongings and went away. My description of him as a brute is not exaggerated.

In great contrast with this behaviour was that of the common soldiers quartered upon us in the regular way. They were pleased with everything one gave them. There were about a dozen to begin with, who established themselves in the hay-loft, and such space as there was over the coach-house.

In their free time they played about with us boys and explained the working of the breech-loading rifle, which was then a novelty. When, later on, the number of men we had to feed and lodge was more than doubled, they crowded together and made a joke of it; all were Rhinelanders, I am pleased to say.

Dr. Schütz, in his moments of patriotism, used to say that Prussia was called the land of civilization, because everything went by clock-work. The organization of the requirements for food supplies of the quartered troops certainly bears out this contention.

On the day of entry into Frankfort, the commanding general, von Falckenstein, published the following announcement:

‘In reference to my army orders issued at Hanover on the 19th June, I order that [as regards] the maintenance of the soldiers of the army of the Main, while it is under my command in an enemy country, shall be as follows:

Officers and officials of equal rank (these as enumerated in the document) shall demand:

In the morning: coffee, with accessories.

At noon: soup, meat, vegetables, roast meat, and one bottle of wine.

In the afternoon: coffee.

In the evenings: supper, and, in addition, eight good cigars daily.

Soldiers quartered in the town receive:

In the morning: coffee, with accessories.

At noon: one pound of meat, vegetables, bread, and half a bottle of wine.

In the evening: supper and a seidel (about $\frac{3}{4}$ pint) of beer, and, in addition, eight cigars'.

These regulations are the same as those that had previously been enforced at Hanover except that, as regards the cigars supplied to officers, the adjective 'good' had been added.

On the 18th July, Falckenstein made a demand for:

1. A pair of boots for each soldier.
2. 300 trained riding horses.
3. Soldiers' pay for each soldier of his army to cover expenses for one year.

The sum agreed upon for the payment of soldiers' wages amounted to 5,747,008 gulden, which at the current value of the Frankfort gulden amounted to about £490,000. This was paid at once through the Frankfort Bank, which had no difficulty in raising a loan at 5 per cent. interest, repayable in one year. This payment will be referred to as the first contribution.

Were it not for a tragic calamity that soon was to cast its shadow over the unhappy town, one might find a touch of humour in some of the events.

My father was fond of telling how, when the bank had declared itself ready to pay in cash the contribution of about four hundred and ninety thousand pounds, agreed upon as providing for the soldiers' pay, the army authorities sent a wheel-barrow to fetch the money. It was in fact paid in silver and required eight railway trucks for its transport to Berlin!

Another episode is also worth recording. One day the family were sitting round the dinner table when a messenger arrived with a pressing summons for my father to come at once to a meeting of bankers, as urgent matters had arisen. He went, of course. On his return, he told us that a new demand had been sprung upon the resources of the city, which was now ordered to pay, within twenty-four hours, an additional sum of twenty-five million gulden, or nearly ten times the amount previously handed over, which they had had every reason to regard as final. The meeting naturally was in deep distress, especially at the shortness of the time-limit. Only the head of the Rothschild firm¹ seemed calm. He asked to see the document containing the demand, and after looking at it he smiled. 'This does not worry me', he said, 'the document is worthless because it bears no date, and we can start the twenty-four hours whenever we like'. The situation was thus saved for the moment.

At the same time it is instructive to trace the succession of events which made it possible for it to have arisen.

The headquarters of the Prussian army, at the time, were in Bohemia, where the Prussians were pitted against the Austrians. The King of Prussia and Bismarck were both staying at headquarters when the Prussian army occupied Frankfort. It appears that General Falckenstein, in demanding and obtaining what we have called the first contribution of five million gulden from Frankfort, acted entirely on his own responsibility. Meanwhile the King,

¹Mayer Carl von Rothschild (1820-1886).

together with Bismarck, on hearing of the occupation of Frankfort by Falckenstein, had a telegram sent to him in cipher, which decoded reads as follows:

'I request your Excellency by command of the All-Highest to impose on the town of Frankfort a contribution of twenty five million gulden'.

To complicate matters, Falckenstein was suddenly called away on his appointment as Governor of Bohemia, and General Manteuffel took his place at Frankfort. It then became his duty to give effect to the King's telegram. In doing so he took the liberty of omitting the words 'By command of the All-Highest'. This, he explained in a pencil note, was done on the ground that the King should not be mixed up in such unpleasant matters, and that the King could exempt from contributions but not impose them.

I think we must therefore draw the inference that it was Manteuffel who was responsible for the drafting of the document demanding payment of the second contribution of twenty-five million gulden within twenty-four hours, which was left undated.

Some newspapers unfortunately made injudicious remarks to the effect that rich men in Frankfort had transmitted money and valuable articles for safe custody to Paris, London and other foreign towns. This incited the Prussian authorities to take further action against the wealthy population of the town. As a preliminary measure, General Röder¹ wrote to Fellner, the senior burgomaster of the town, asking

¹Schwemer, *loc. cit.*, vol. III (2), pp. 355-6 and 542.

him to provide a list of the names of the citizens holding public positions, noting especially those who possessed houses of their own. It may be imagined that to a man of fine feelings, such a task must have been abhorrent, though it appears from the documents that the object of the list was only that of quartering a greater number of troops in the town. Be this as it may, Fellner was found next morning dead, hanging from a tree in his garden, with a beginning of the list on his writing-table. This is the tragedy alluded to above. I felt it personally, because Fellner's son was my best, or I might more correctly say, my only school-friend.

The news of Fellner's suicide could not fail to increase the bitterness of feeling between the inhabitants of the town and the invading army. But the war was nearing its end, and on the 8th October Frankfort was formally incorporated as an integral part of the kingdom of Prussia. Its internal constitution was, however, wisely left as nearly as possible without material change, and Frankfort has not lost any of its importance. In the year 1800 the number of its inhabitants was 40,000; it rose to 78,000 before the war of 1866. Under the Prussian regime this number has risen still further and stood at nearly 290,000 in the year 1900.

Before closing this chapter, two episodes remain to be told. The scene again is in the open space in front of my father's garden where I first saw the Prussians enter the town. In my mind's eye it is now filled with soldiers crowding round Manteuffel, who apparently takes up a persuasive attitude. There is obviously some turmoil which the general tries to

soothe. Next day I heard, probably through the servants, the cause of the commotion. The war was over and the soldiers had been discharged, but were expected to pay their own expenses for the homeward journey. This they naturally resented. The story goes that Manteuffel calmed them by the promise that a special train was going to be placed at their disposal. When the special train came they were made to enter it, but instead of taking them back to their own country, it deposited them in the fortress of Mayence.

All visitors to Frankfort will be familiar with the Cathedral or *Dom*, the building in which the Emperors of the Holy Roman Empire were formerly elected and, after 1562, crowned. In my younger days the tower was used as a station which served to give signals when a fire broke out in the town. The watchman used for this purpose a gong or similar instrument, which could be heard at the different fire-stations. One stroke meant a conflagration of small importance. If the fire increased, a second stroke was given, and so on until a maximum number was reached, which I believe was five. The first and last time at which it became imperative to give that highest danger signal was on the 15th August 1867, when the cathedral itself caught fire. The watchman in charge must have had some sense of the dramatic. He stood at his post until the fire reached the wooden stairs of the tower, sounded his gong five times, and rushed down to save his life. I had gone to bed, sharing a room with my brothers, when Dr. Schütz came in, and I recollect the very words he used: 'Children',

Aet. 16

he said, 'if you want to see your *Dom* once more, get up at once. It is burning'. It was indeed a wonderful sight; the whole tower was a sheet of flame. There was a high wind at the time, and the next day we could pick up half-burnt leaves of prayer-books in our garden, which was about a mile away from the fire.

It is a curious coincidence that the fire broke out on the eve of the day that King William had chosen to visit Frankfort for the first time after the incorporation of the town in his kingdom. No importance need be attached to the report that, when he went, during his visit, to look at the damage done, a fireman turned the hose on him; but I cannot help quoting an old German verse, which to some evilly-disposed persons may seem prophetic. It is found, as Schwemer gives it, in a collection of German sayings published in 1718 and runs:

‘*Zu Frankfurt in dem Dom
Gibt man des Reiches Kron;
Willst du mit List die Krone fahn,
Wird Gott den ganzen Dom zerschlahn—*¹’

meaning that rather than see the Imperial crown surreptitiously taken away, God will destroy the *Dom*. But the *Dom* in this case was not destroyed. On the contrary an opportunity, of which good use was made, was given to the Prussian authorities to complete the building of the tower, which had been left unfinished. It now stands as designed by Hans von Ingelnheim in the fifteenth century.

¹Schwemer, *loc. cit.*, vol. iii (2), p. 484, with a footnote reference to the ‘Spruch’ in *Deutsche Kern- und Reichsprüche*, Altdorf, 1718.

VI. AN INTERLUDE

THE greater part of the war of 1866 fell within the summer vacation, so that on the whole the course of studies was not much affected. My own form at the time was *tertia*, which is the third highest form. This was followed by *secunda*, to which I was promoted at Easter 1867. The normal period for remaining in that form was two years, reduced to one year in exceptional cases. I both could not and would not aspire to such distinction, and that meant leaving school for good without reaching the highest form. Act. 15

The course of education mapped out by my father for his sons included the spending of one year in a French-speaking country, and this in any case would have led to my leaving Frankfort about this time.

There was, however, a much more important reason for our departure, which arose from the events recorded in the last chapter. A complete change had taken place in the national status of Frankfort. Up till the autumn of 1866 it had been a Free City and an independent state, ranking also as a federal capital. It then became a Prussian town, and all its male inhabitants of a certain age were liable to military service.

Anti-Prussian feeling was quite general and ran very high, and my father decided to emigrate with his whole family in order to avoid Prussian nationality. He had always had a small share in the Manchester branch of the family business, and it so happened that just about that time there was a chance of his attaining a senior partnership, owing to the death of one of his uncles. It was easy for him to change his nationality, as he was of course far above the military age. As for us children, we went through the formality of obtaining a domicile outside Germany, and this could be done by financial arrangements in one of the Swiss cantons. My brothers and I myself became temporarily citizens of Schaffhausen, and thus bridged the interval until we could be naturalized in Great Britain, as we were in 1875.

Aet. 16 I left school at Easter 1868, the intention being that I should, in the autumn of that year, continue my studies at Geneva. A certain interval had therefore to be bridged over. As I have mentioned earlier, this gave me a welcome opportunity of making some advance in mathematics under Dr. Schütz. I also went once or twice a week to the laboratory of an analytical chemist, in order to obtain some knowledge of the elements of chemistry. In addition to this, and with a view to my entering business in due course, my father engaged one of the masters of a commercial school to teach me book-keeping and ordinary stock-exchange transactions. There were also lessons in French and English, and, what I enjoyed above everything else, an afternoon a week spent in the

studio of a painter, who taught me the elements of water-colour drawing.

Among the incidents of this period, my memory recalls one which I believe to have indirectly affected my future career. It was the death of Faraday, which took place on the 25th August 1867. I had been looking from time to time into books on experimental physics, and the name of Faraday was familiar to me; but, not being particularly interested in historical matters, Faraday was only a name. He might have lived ten or a hundred years ago. When I read his obituary notice in the press, the revelation that great experimental discoveries could still be made came almost as a shock; and the idea of devoting my life to physics began to take hold of me. My ambitions ran high and, like many amateurs, I attacked the impossible, passing sleepless nights in trying to trisect an angle or invent a method of obtaining perpetual motion. Dr. Schutz tried to restrain me, but, as already explained, I had lost faith in his infallibility.

This interlude passed quickly, and in the autumn of 1868 I was ready to proceed to Geneva, where my father had found a suitable family, with whom my elder brother had just spent a year. Aet. 17

VII. GENEVA AND FREEDOM

Aet. 17 ATTRACTIVE surroundings, effective liberty, and congenial work are all that a man should want for complete happiness, and these I found in abundance while remaining in the care of Pasteur Goetz at Geneva.

The main object of my being sent to Geneva was to learn French. I already knew enough to get on in ordinary conversation, so that Pasteur Goetz could concentrate on the literature of the language. He made me write essays and learn classical poetry by heart. I can still recite some verses of La Fontaine, Lamartine, and Victor Hugo.

Madame Goetz helped by listening to my reading aloud to her for a short time each day.

There were four pensionnaires, besides myself, under the supervision of the head of the house, and the family consisted of four sons and one daughter. One of the sons was seldom at home, being an officer in the cavalry; another was just leaving to study medicine in Paris; and the two youngest were still at school. We were altogether a happy family, and we made frequent excursions into the surrounding country. In Switzerland as in France, half-holidays on Wednesdays and Saturdays are replaced

by a whole free day on Thursdays, which allowed us to go quite far afield in our rambles.

As my studies of the French language only occupied a small fraction of my time, I also attended lectures on various subjects at the 'Academy'. This institution, founded by John Calvin, was served by teachers of high reputation, many of them drawn from old Geneva families, such as de Candolle, de la Rive, Soret, and Plantamour. Since then the Academy has acquired the status of a university.

To fill my time-table, the Academy offered an attractive series of lectures. I selected a course on mechanics by Cell  rier and one on molecular physics by Soret. I took copious notes during these lectures and wrote them out carefully at home. Judging by these documents, which I have preserved, the lectures were of a high University standard. In addition, I attended some lectures on history, not because I wanted to know something about the subject, but on account of the personality of the lecturer. His name was Paul Chaix, and he was reputed to have a phenomenal memory. The story went that when a traveller passed through the town he was often confuted by Paul Chaix, who asked him awkward questions on the width of some river he had traversed, or the height of the mountains he had ascended. When my turn came later to start on travels, I got over this danger by writing to him beforehand, asking whether there was any information I could get for him. In the meantime I passed some pleasant evenings with him at his home, two or three miles from the centre of the town, where he lived with his two daughters.

It was a happy time. The proverbial fly in the ointment had to be searched for, but could perhaps have been found in a small estate belonging to Pasteur Goetz between Geneva and Bellegarde. This included a vineyard, the wine from which we had to drink at meal-times. I even got over this small inconvenience by making the doctor prescribe beer for me.

When I speak of the time at Geneva as a happy one, I cannot fail to remember a strongly contributing cause. Owing to my mother's state of health, my father's immersion in business matters, and the fact that I am twelve years older than my only sister, I had never had occasion for friendly association with members of the fair sex; while at Geneva, three charming girls, cousins of the Goetz family, shared in our recreations, and were practically on the footing of sisters.

The Christmas festivities included private theatricals in which I played a leading part; but towards the end of the winter session, I had a bad attack of bronchitis, and after a few weeks, in which I did not seem to get better, I was sent home. There I found my parents getting ready for migration to Manchester.

In the meantime Dr. Schütz had married a Frankfurt girl, and a successor was appointed, who took my brothers and me on a walking tour through the Bernese Oberland. At the end of July or the beginning of August, I returned to Geneva, accompanied by my younger brother.

The winter session at the Geneva Academy began in October, and I selected for closer study during that period two subjects of widely different interest.

Emile Plantamour, the professor of astronomy and director of the Observatory, was a pupil of Bessel, and a scientific man of distinction. When I told him that I wished to attend the lectures which he was announced to deliver, he replied that, as I was the only prospective student, he proposed that I should come for instruction to the Observatory. This I did with benefit to myself, learning something of elementary astronomy, and of the routine work of the Observatory. My second choice was comparative anatomy, a course intended no doubt for medical students. I don't remember what attracted me to that subject unless it was the report that the professor of zoology, Claparède, was a great adherent of the Darwinian theory of natural selection. Of this he made no secret, in spite of the great opposition encountered in a strongly Calvinistic institution. In his opening lecture he told us that a great prejudice prevailed, the belief being general that everything in this world had its utility, but he went on to ask, 'Of what use are the teats of a man?' His own view was, that just as we have in language mute letters that serve no object except that of indicating the history of the word, so there are anatomical structures that are of purely historical interest. I don't recollect any further references to this tender subject, but do not expect that I attended the lectures very regularly.

I find among the manuscripts which are still in my possession a notebook of one hundred and thirty-one pages, bearing a label with the inscription *Paul Chaix—Géographie Commerciale (Private Tuition)*. I had entirely forgotten this, but it now comes dimly back to my memory that I did at times visit

Professor Chaix at his home for some such instruction. In the manuscript referred to, materials used in commerce are divided into groups, such as metals, precious stones, and fuels; and the localities are indicated where these materials are found. As the title indicates, the study of commercial geography was expected to assist merchants interested in the imports and exports of important raw materials.

Among the lectures I attended I must not forget those of Marignac, the eminent chemist.

Act. 18 It had been arranged that my brother and I should join the rest of our family for the Christmas festivities of 1869 in their new home in Manchester, where my father had bought a house in Stanley Grove.

Owing to our absence from Geneva, we could not take part in the annual amateur theatricals of the Goetz family, but on our return from Manchester, my brother organized a performance of *The Toy Symphony*, and those who know my incapacity to appreciate music will be surprised to hear that I took part in it, playing the triangle.

Our journey to England was interesting, as it gave us the unusual experience of getting a first view of the two great capitals on two successive nights. My father had written to the manager of an hotel in Paris where he was known, ordering a *simple* dinner with light wine, and asking him to look after us generally. The simplicity was not quite obvious, but it served its purpose, especially as we had asked Edward Goetz to meet us at the train and spend the evening with us. We met him, as arranged, and after dinner he took us for a stroll round some of the boulevards and to look at the Tuileries, fated to become an empty,

though always beautiful, ruin within the next eighteen months (in May 1871).

We continued our journey next day, the sea being, fortunately, smooth. My father met us on the landing stage at Dover, and after a short welcome handed me a little poem, which my elder brother had composed in honour of our arrival. During the evening in London my father took us for a walk through Regent Street, Pall Mall and Trafalgar Square. Of the two cities, I found London much the more impressive, especially the sight of Trafalgar Square.

Our stay in England was short, as we had to go back to our studies. I remember the bitterly cold journey through France at night.

During the winter of 1869 I had my first experience of teaching. A small boy, perhaps ten or twelve years old, came to me, declaring that he wanted me to teach him to talk German. His father was, so far as I can recollect, a shoemaker, and a parishioner of Pasteur Goetz, who gave him a good character; and so we arranged for some lessons. The boy was quick to learn and got on well, until suddenly one day he ceased to appear, and on making enquiries I was told that he had run away from home. The father was quite angry with me for teaching him so quickly, and explained the real reason for his wish to learn German. They had relations in German Switzerland, and the boy preferred to live with these relatives rather than with his parents in Geneva. His father had given as a reason for not letting him go away that he could not talk German, and this excuse was now no longer available.

My second experience in teaching is mentioned in

the diary which I kept spasmodically during these years. One Monday—the entry runs—an individual named Köhler wanted to learn about logarithms before the following Friday, and came to me for an hour's teaching every day, which took up much of my time.

The entries in my diary, with their references to dances that lasted till midnight, excursions on foot or horseback, and other amusements, are signs of the good times we had during the winter months; and then the inevitable blow fell.

Aet. 18 Towards the end of May I received a letter from my father, informing me that he had decided to send me to Frankfort after the summer holidays, so that I might learn the banking business. I knew of course that the happy days of Geneva could not last for ever, and feel sure that my father did not wish to prejudice my future career; but working in a banking house for a year did not seem to him to exclude alternatives. In the discussions that ultimately followed, I was constantly reminded that Sir John Lubbock was a banker who had also secured a scientific reputation. It was further pointed out to me that the firm of Schuster Brothers was interested in print-works, where men having a knowledge of chemistry were required. Rightly or wrongly, this did not satisfy me.

I shall never forget what I owe to Geneva, and do not feel ashamed of the tears I shed when, on the 25th May 1870, the engine that took me homeward steamed out of the station.

VIII. EARLY YEARS IN MANCHESTER

LEAVING Geneva on our way home, we did not take the direct route, but passed through Frankfort, where we stayed a night with my father's only sister, Frau Henriette Flersheim. In the meantime my parents had taken a house at Lytham, a seaside resort which had been recommended to them by a friend as the Nice of England! My father never forgave the friend. To make up for the unattractive dullness of the place, we three brothers were taken for a trip through the Scotch Highlands. The recollection of Oban and of Lochs Katrine and Lomond, as well as of other famous sights, is impressed on my memory; but more strongly still remains the shock received when on the homeward journey we heard newspaper boys shouting 'Declaration of War'. It was indeed the beginning of the Franco-German War of 1870.

In the record of subsequent events, of which I have preserved a fairly complete account, I am surprised to find no mention of my work as a member of the firm of Schuster Brothers, which I must have joined as an apprentice during the autumn of 1870. Trusting to my memory, I find myself sitting in the office in Sackville Street, Manchester, copying letters, checking additions, paying weekly

Aet. 19

wages and performing the work of an ordinary clerk. The occupation was entirely uncongenial and my opinion of it is expressed in a passage of my diary declaring that I can only find happiness in a scientific career. The passage bears the date of 7th October 1870, beginning and ending with the somewhat melodramatic Latin tag *alea jacta est* (the die is cast).

Aet. 19

This courageous exclamation remained for the time being without result. The surrender of the French army at Sedan, followed by the occupation of Paris and the destruction of the Tuileries, absorbed all interests. My scientific aspirations had to be satisfied with the reading of scientific books, such as Darwin's *Origin of Species* and Tyndall's *Heat considered as a Mode of Motion*, and attending Roscoe's evening classes in chemistry, at Owens College, for which I obtained the prize at the examination that followed in the spring.

The crisis came during the following summer. On the 23rd June 1871, according to my diary, my mother, with the sympathetic insight of some blind people, told me that she felt I was unhappy, and asked whether the prospect of my future life as a business man was the cause of it. For the moment I was overwhelmed by surprise and, hardly knowing what I was doing, denied the existence of any discontent. Within the next few days, however, I realized my mistake and confided my real feelings to her. She explained the situation to my father, who took a very reasonable view. While adhering to his own opinion, that business should be my ultimate destination, he did not object to a postponement of my entry into it for another year, and even agreed

that we might, in the meantime, obtain Roscoe's opinion as to what opening there was for me in a scientific career. The only fear he expressed was that I should waste his hard-earned money on wild-goose chases, such as attempts to construct dirigible balloons.

I was glad to see Roscoe chosen as consultant in the matter, because already at Frankfort I had come across his little treatise on chemistry, showing in the frontispiece coloured prints of the spectroscopic lines of the alkaline metals. This had attracted my attention, and in my free time I had tried to discover some relation between the wave-lengths of the different lines. Like others, notably Johnstone Stoney, I had hoped to find a connexion like that of the overtones of a musical note; but this belongs to a different chapter.

My interview with Roscoe will remain for ever impressed on my mind. We walked about in the garden of the house built for him in Victoria Park by his father-in-law, Edmund Potter. He explained to me the difficulties of earning a living by scientific research, while such a living stood ready to my hands if I followed in my father's footsteps.

After some further conversation, in which he showed interest in my attempts to detect harmonic relations in the wave-lengths of spectroscopic lines, he closed the conversation with the words, 'I hope you will join the ranks of scientific men'. This was the beginning of a lifelong friendship. To my father he recommended that I should enter the day-classes of Owens College for a session, studying physics under Balfour Stewart, and then, if I showed

the necessary aptitude, follow this up by taking a degree at a German University. To this my father agreed, and I looked forward to my future with greater happiness than I had ever known before.

I cannot fix the exact date of my interview with Roscoe, but it must have been towards the end of July 1871. There was therefore an interval of a month or two before the beginning of the college session and this was partly filled by a walking tour in the Welsh mountains. This remains in my memory because it was the only occasion on which I had an opportunity of seeing the remarkable optical effect called the 'Spectre of the Brocken'.

Aet. 20 When work began again early in October 1871, I found my time-table well filled. Besides Balfour Stewart's lectures on physics, I took courses in pure and applied mathematics, given by Thomas Barker (a most excellent teacher); and one or two days were spent in the laboratory.

By the wish of my father, I took some private lessons in Italian, and I also had instruction in the English language from a member of the Herford family. Some time was also taken up by social functions, such as dinner parties, dances and even the Hallé concerts. I am afraid that musical enjoyment was not my inducement to attend the concerts, but the long interval in the middle gave opportunities for short conversations with one's friends; and I believe that there were quite a number of listeners besides myself who came for the purpose of making use of these opportunities.

My chief interests lay, of course, in my work. Owens College, at the time, was still housed in Quay

Street, the physical laboratory being at the top of the building and much affected by the vibrations caused by passing vehicles. A former professor (R. B. Clifton), who was particular about the accuracy of his measurements, is indeed reported to have declared that the only research he could carry out in the so-called laboratory was to determine the kind of vehicle that was passing in the street below, by observing the nature of the seismic disturbance.

The equipment of the laboratory, when Balfour Stewart took charge of it, consisted of the barest outfit for lecture-room illustrations, and the most urgent needs had to be supplied by the instrument-makers before any start could be made. Roscoe helped us out to some extent on the optical side. Balfour Stewart himself, who had only been appointed in 1870, was new to the routine of a laboratory.¹

Spectrum analysis was then in its early stages, more especially as regards the spectra of gases. In the year 1864 Plucker and Hittorf had published their researches, which led them to the conclusion that one and the same elementary body could give two different spectra, according to the conditions under which it is rendered luminous. If excited by an electric discharge of strong intensity it would show a spectrum of sharp lines, while a weaker intensity would give bands that could only be resolved with sufficient dispersion into closely adjacent lines. Ångström, in Sweden, supported by most English observers, did not admit the possibility of more than one spectrum for an elementary body, and contended that when two or more were apparently shown this

¹For a sketch of Balfour Stewart's life, see p. 206 below.

was due to the presence of an oxide or other compound which had unwittingly been introduced. Roscoe proposed to me that as a first research I should try to settle this question, and Balfour Stewart suggested that in order to absorb unwanted oxides, metallic sodium might be introduced into the tube.

The results of my experiment seemed decisively in favour of the view that pure nitrogen has only one spectrum, a spectrum of lines, and that the band spectrum was due to oxides formed under the influence of the electric discharge. The paper in which I described the experiments was published in the Proceedings of the Royal Society, and referred to in the Presidential address delivered at the end of the session by Sir George Airy. Nevertheless some doubts arose and the opposite view prevailed in many quarters. It was to M. G. Salet, Maître de Conférences at the Sorbonne, that we owe the final decision.

In view of its historical importance I reproduce here a translation of Salet's summing up, as it appeared in the English translation published in the *Philosophical Magazine* (April 1876, p. 331):

'Mr. Schuster made public in 1872 the important fact that nitrogen, heated in a Geissler tube with metallic sodium, no longer gives its characteristic grooved spectrum. He described the bright lines obtained in this case, and attributed them to pure nitrogen—the band spectrum being, in his opinion, that of an oxide of nitrogen, a compound which is destroyed by the alkali-metal. Later, doubts arose concerning the validity of these conclusions; for, on the experiments being repeated, the grooves were indeed seen to disappear after the action of the sodium, but they were replaced by

various spectra, of which not one really belongs to nitrogen, so that after purification this gas could no longer be detected by the prismatic analysis. I have also remarked that the chemical compound which is in reality formed by the action of oxygen upon nitrogen is the peroxide, a very stable body and one the spectrum of which does not at all coincide with that of which we have to account for the appearance.

My present purpose is, to demonstrate (1) that the grooved spectrum can be produced with nitrogen heated in contact with sodium, (2) that the disappearance of the spectrum of nitrogen is due to the disappearance of the nitrogen itself, it being entirely absorbed by the sodium under the influence of the electric effluvium, and (3) that the spectrum described by Mr. Schuster is very probably to be attributed to the vapour of the alkali-metal'.

It has sometimes occurred to me that a skilled and inspired observer might, at this stage, have found the clue and been led to the discovery of argon; but the history of science is full of 'might have been's' and I have always held that to come near a discovery, and not to make it, only emphasises the failure.

Curiously enough, my chief ambition at the time was not extensive research, but the acquisition of experience. I looked upon my investigation on the spectrum of nitrogen as being a partial failure, and in the written record which I have preserved I find indeed a note indicating that I committed a mistake in starting research too soon. To supply the deficiency, I desired to acquire personal knowledge of the working of different laboratories, more especially as this might give me opportunities of becoming acquainted with some of the leaders of science. I acted in accordance with this policy and never regretted the result.

IX. HOW I BECAME A DOCTOR OF PHILOSOPHY

Aet. 21 HAVING completed a year's work at Manchester, my further course of studies had to be decided upon. I was attracted by Cambridge, but Roscoe strongly advised Heidelberg, and his opinion carried the day. I consequently proceeded to Germany in the summer of 1872 with introductions to Kirchhoff and Bunsen.

My first visit to Kirchhoff was disappointing. I had hoped that, according to German custom, he would suggest some subject for experimental research which might ultimately serve as a thesis for the degree; but I found him mainly interested in theoretical questions, and his laboratory was poorly equipped for experimental work.

The subjects of physics and physiology at Heidelberg shared, at the time, a large building in the Hauptstrasse, called, if my memory serves me right, the Friedrichsbau, which contained also the private residences of the two professors. The part assigned to physics included, in addition to the professor's library and private study, a spacious lecture-theatre, a smaller room for instruction in elementary practical work, and one room that could be devoted to re-

search. This was occupied by Lippmann, who was then engaged on the classical experiments which led to the construction of the capillary electrometer. The only other research student—Kamerlingh Onnes—had to be satisfied with a corner of the lecture-room, which was generally free during the greater part of the day. The three of us here laid the foundation of a lifelong friendship.

I explained to Kirchhoff that it was my intention to present myself for the degree of Ph.D. in about a year's time, and he suggested that I might turn my attention to the reflexion of light from metallic surfaces. He offered to place a small instrument suitable for the study of elliptically polarized light at my disposal, but expressed doubts whether I should obtain any results of value in the available time. Though his forecast proved to be justified, I did not regret the six months spent on the work, as I gained knowledge of the literature of the subject, and experience in the use of delicate optical appliances.

The conditions of admission to the German universities have always been distinguished by their liberality. 'Freedom to learn and freedom to teach', *Lern-Freiheit und Lehr-Freiheit*, is the slogan which embodies their ideals and expresses the German's pride in institutions which have substantially preserved their independence, even in times of trial.

I registered my name as a student of the University on the payment of a small fee, without having to produce any evidence of previous education. This fee entitled me to attend, without further payment,

three lectures of any one course, and much use was made of this privilege before deciding on a final timetable. A popular lecturer's room was often crowded by such temporary students, who sometimes came from a distance to listen to him, especially as a liberal interpretation was given to the number of free attendances.

Kirchhoff used to give an elementary course of lectures on experimental physics, and an advanced course on some branch of mathematical physics. Practical work was provided for by selecting some simple exercise, such as the determination of a refractive index or of the horizontal component of terrestrial magnetic force. As only a single set of instruments was available, the number of students who could be admitted to the course was limited to about ten. Once a week the class met, when the professor discussed the results obtained and explained the exercise for the following week.

Towards the end of my first semester I began to think of presenting myself for examination. The regulations required that in order to obtain the degree of Ph.D. candidates should pass an examination in three out of a number of specified subjects, one being the principal, and two subsidiaries. I chose physics, mathematics and chemistry, with physics as the principal subject. I knew but little chemistry but was not aware at the time that I might have substituted mechanics, which would have suited me much better.

A difficulty arose through my not having passed the *Abiturienten Examen*, which is the recognized school-leaving examination in Germany. Ultimately

a certificate that I had reached the standard of *secunda* in the Gymnasium of Frankfort was accepted, on condition that I should submit myself to an additional examination in Latin. On the standard of knowledge demanded in the different subjects I had practically no information, the examination being all *viva voce*, with no permanent and accessible records of the nature of the questions asked. I had once asked Kirchhoff whether he could give me any indication or recommend me some book which I might find useful to read. He answered briefly: 'I shall examine you in physics'. With so little to guide me, I have since often wondered that I had the courage to face the ordeal at that stage.

A few days after giving notice to the proper authority, I received a summons to present myself on a stated day, about a fortnight later, at the University office at 7 o'clock in the evening. The examination was to last two hours, one of which was given up to the principal subject.

There was a curious custom in Heidelberg, as probably also in other German universities, which required candidates to visit the examiners personally on the day previous to their examination. Full evening dress was customary. When the day arrived, my first visit was to the examiner in Latin, who explained to me that he saw no reason why a man of science should know ancient languages. We spent quite a happy quarter of an hour together, when he closed the conversation by asking me whether I had ever read Julius Caesar. Receiving an affirmative reply, he told me that he would ask me to translate a particular passage in the second book of the *De Bello*

Gallico, 'but that he would pass me however badly I did'.

My next visit was to Bunsen. On ringing the bell of his private apartment, I saw the door open just sufficiently to allow his stately figure to fill the gap. 'Ah, Herr Schuster', he said, 'I know you are coming up for your examination to-morrow, and you are very busy. I must not detain you', whereupon the door shut again.

My third examiner was the mathematician Königsberger, who, as usual, was friendly and entertaining. I do not recollect that the examination was referred to until the end, when, conducting me to the door, he whispered: 'Kirchhoff is very fond of asking questions about the potential theory'. I thanked him for the tip and departed. I had every reason to be satisfied with the procedure so far.

On the evening of the day following these formal visits, I presented myself at the University office and was shown into a large room, the centre of which was occupied by a long table, holding about ten chairs on either side. Most of these were gradually filled by the members of the faculty, whose attendance was secured by a small fee. The Dean took the chair at the head of the table and I was asked to take a seat near the middle of one of the long sides. Seven o'clock struck and the examination began.

Latin was taken first and I got on fairly well until the word *frumentum* occurred. I translated this by the German word *Korn*, whereupon the chairman shook his head in disapproval, and as I looked up saw that shake pass like a wave along the distinguished audience. It was explained to me later that

frumentum was a general term, while *Korn* only applied to a particular cereal. I ought to have used the more general term *Getreide*. I do not remember any other mishap and the first part of the examination was soon over. Kirchhoff next came to sit by my side and I was curious to see whether Königsberger's tip would come off; it did not! My examiner opened by referring to my work on spectrum analysis and asked some simple questions on the optics of the spectroscope. He then switched off, entering into the complications of double refraction and wave-surfaces. I stood my ground fairly well, until the equations got a little beyond me. In trying to help me out, Kirchhoff got stuck himself. 'We are both rather stupid over this problem', he remarked, and closed the examination.

Eight o'clock struck, when there was a quarter of an hour's interval for refreshments. Wine was handed round, and some of the examiners came to express their sympathy by some encouraging words. All through the examination it appeared to me that the examiners rather took the part of advocates of the candidates against the gallery of dummy professors who were paid to be present.

When we took our seats again, I received a shock. There were two professors of chemistry in Heidelberg, Bunsen and Kopp, and I had taken it for granted that Bunsen would examine me. But Bunsen was absent, having probably forgotten all about the examination. It was the severe Kopp who took the chair beside me.

He started off by trying to find out how much I knew about the determination of atomic weights, but

soon found out that Dulong and Petit's law was the alpha and omega of my knowledge about them. I confess that I did not make a good show, but felt the atmosphere soon clear again when Königsberg took the examiner's chair. He dealt mainly with simple differential equations and matters he had discussed in the colloquium. There was no shaking of heads by the audience. The examiner's last question was on the meaning of the expression *der letzte Multiplikator*. When I declared my ignorance he was good enough to close the examination, saying 'There is really no need for you to know this.' I found later that my ignorance of the term was a question of language rather than of mathematics.

At nine o'clock, the chairman rose, and I was asked to withdraw to an adjoining room. About ten minutes later I was called back and informed that I had passed the examination and was to present myself next morning to deliver the oath and to have the degree formally conferred. There are four classes in the degree examination, bestowed according to the examiners' estimate of the candidates' knowledge. Those who have given complete satisfaction in the examination are rewarded by having *summa cum laude* inscribed on their diploma. I had to be content with the second-best qualification, *magnum cum laude*, which is better than the simple *cum laude* or the plain doctorate, deserving no special praise. I was told privately afterwards that the loss of the 'highest praise' was due to my partial failure in chemistry.

On my appearance next day at the proper time at

place, the oath was read to me in the Latin language. Of the obligations to which I may have committed myself by the oath, there is only one that remains in my recollection. This was the promise not to take a degree in the same faculty in another German university. I have often referred to such a restriction as having its merits, but, to guard myself against any defects of memory, have recently tried to obtain the exact wording of the obligation imposed. The present librarian of the University, to whom I applied, was good enough to reply that he was aware of the condition not to take a second degree (except in another faculty) as having been imposed by oath in the middle ages, but that he had no knowledge of its still being enforced in the year 1873.

In most German universities, the viva-voce examination had to be supplemented by a dissertation showing some capacity for original work. This was not a *sine quâ non* at Heidelberg in my time, but the candidate who failed to produce an approved thesis had to deposit a sum of about £10, which was sequestered if the omission was not made good within a year. This I intended to do. A week or two after the examination I met the librarian of the University, who, while congratulating me on my success, expressed the hope that I would not trouble about the dissertation. The reason for this request, as he explained, was that the sequestered money was handed over to the University library and was the only source of its income. As this left me greater freedom in the choice of further research work, I readily gave way to his persuasion, and this is the way I became a Doctor of Philosophy.

Incidentally it may be mentioned that the examination for this degree was the only one of any importance to which I ever submitted myself.

Aet. 22 After the year spent at Heidelberg¹, I returned to Manchester, and in the autumn of 1873 I became the first demonstrator in the Physical Laboratory of Owens College, Manchester (now the University of Manchester). This was the first session after the removal of the college from Quay Street, where I had studied, to its present site.

I followed this up by spending the summer of 1874 at Göttingen in the somewhat primitive laboratories of Wilhelm Weber.

The work I was engaged upon at the time was based on an experiment which seemed to indicate that the effect of a weak electric current could be increased or diminished by a superposed rapidly alternating current. An account of the experiments was printed in the *Philosophical Magazine* and the *British Association Report* for 1874. It raised some controversy at the time but has no further interest.

Aet. 23 Having gained some experience at Heidelberg and Göttingen, it was my intention to conclude what one may call my educational course in the laboratory of Helmholtz at Berlin. Roscoe's introduction secured me a good reception, and I was glad to obtain the approval of Helmholtz for the subject of research which I had in my mind. The experimental arrangement I proposed to adopt he declared to be 'elegant', of which I was not a little proud.

¹Some further account of my experiences in the University of Heidelberg is given on pp. 216-220 below.

Helmholtz continued to show interest in my work while I remained in Berlin, but my memory fails me entirely as to the object of my experiments. The only impression that remains is that of a sphere of Iceland spar which figures as one of the experimental accessories.

I returned to Hampstead, where my father then lived, for Christmas 1874.

X. THE SIAMESE ECLIPSE EXPEDITION OF 1875

Aet. 23 IN the course of the last few days of 1874 I received a letter from Norman Lockyer asking me to join an expedition which was being fitted out to observe the total solar eclipse due to take place at the beginning of April 1875. The letter reached me on my return home from Berlin for the Christmas holidays. I called at once on Lockyer, being only too glad to place myself at his disposal. He told me that the date of departure would have to be the 11th February, in order to arrive in time at the place of observation, and that the Royal Society, which was organizing the expedition, had applied to the Government for the supply of the necessary funds. Nothing was definitely fixed, but it became known in astronomical circles that an attempt was to be made by Lockyer to photograph the spectrum of the solar corona, and the possibility of succeeding in this attempt was strongly denied by a number of experts, headed by R. A. Proctor, a well-known astronomer and popular lecturer. The following is extracted from a letter relating to the subject, and signed by him, which appeared in the *Daily News* on the 26th January 1875:

‘It is said that some enthusiastic students of science propose to try to get photographs, not of the corona as seen in a

telescope, but of the exceedingly faint image seen with a spectroscope. If they should succeed they will have achieved a clever photographic feat, but the results, so far as the corona is concerned, can have little scientific value. It is mathematically demonstrable that this is the case, for the quantity of light actually forming the coronal image can be shown to be far less in amount than is necessary for the formation of a satisfactory photograph'.

Lockyer was not disturbed by such criticism. His attitude was that of a pioneer who tries the impossible if it promises to give him useful hints for the future. Lockyer was obviously marked out for the leadership of the expedition, but his duties as secretary of the Duke of Devonshire's Royal Commission on Scientific Instruction prevented his leaving England for the required length of time, and the Royal Society appointed me in his place. There was no time to lose. Fortunately Lockyer lived within a short distance of my father's house, and I could spend the evenings discussing with him the arrangements he had made and the instructions he was preparing for the use of the observers.

The expedition was to be divided into two parts, of which one was to be stationed on the Siamese coast, and the other on one of the Nicobar Islands. The Royal Society had decided to depend entirely upon photography, previous eclipses having given all the information that was obtainable by the ordinary eye observations.

One of the instruments to be used during the eclipse was a large siderostat with silvered surfaces, and Lockyer was afraid that the silvering might not stand a tropical climate and want renewing. Pro-

vision had to be made for this contingency, which could be done by a new process described by Martin of the Paris Observatory. Lockyer therefore asked me to go to Paris for a few days and get some practice in this process. I went to Paris at once, and spent about a week at the Observatory. I do not think my visit there was of much use, as there were plenty of silvering processes known in England which would have done equally well. Nevertheless I carry away a most interesting recollection of the days spent in Paris, as they gave me an opportunity of becoming personally acquainted with Leverrier.

I have given an account of my interviews with him in a subsequent section.¹

On my return from Paris, my time was fully occupied in speeding up the instrument-makers, and in drawing up the instructions which were to be handed to the observers. There is no need to quote these instructions in full detail, but the institution of a 'time-teller' was undoubtedly a happy idea, which I subsequently made use of on several occasions. The function of the time-teller was to remind the observers of the passage of time, and for this purpose he was to call out, *not* the time that had lapsed since the beginning of totality, but that which was still available for observation. This would give the observers greater confidence and avoid undue hurry. If, for instance, totality lasts four minutes, the time-teller will wait ten seconds after the chief observer has given the signal for the beginning of totality, and then call out 'You have still two hundred and thirty seconds', and so on every ten seconds until the ex-

¹See pp. 198-201 below.

of totality. The time-teller was instructed to take care not to distract himself by losing sight of the face of the watch or chronometer, and it was to be impressed upon him that much of the success of the observations would depend on his undivided attention, as his statement of time would be an order to the observers to do certain work.

So far, all my communications with the Royal Society Committee had reached me through Lockyer, but in the first few days of February I received a document signed by Sir George Stokes as secretary of the Royal Society, which I have carefully preserved. It is sufficiently short to be quoted *in extenso*:

I am to inform you (so it runs) that the Eclipse Committee of the Royal Society have appointed you to take charge of the whole expedition proceeding from England, so long as it remains united, and afterwards of that branch of it which is to go to Siam. Also that the Committee have passed a resolution that the whole of the observations taken by the Siam party be considered the property of the Royal Society, and be sent to that body for discussion.

I am, Dear Sir,

Yours faithfully,

(signed) G. G. STOKES,
Sec. R.S.

4th February 1875.

This document proved to be of great value on several occasions, and, considering that I was less than twenty-four years old at the time, it may, I think, justify the pride I felt on receiving such testimony of confidence.

On the 11th February the expedition embarked on

the P. & O. steamer *Surat* (3141 tons). The Siamese party consisted of two others besides myself: Frank Edward Lott, a young fellow who had just completed his studies at the Royal School of Mines, and who, without possessing any special knowledge qualifying him for eclipse work, proved very useful and handy as an assistant; and Frederick Beasley, a skilled amateur photographer. The Indian portion, which was to separate at Galle in Ceylon, consisted of Raphael Meldola, with the addition of a photographic expert, who had been trained by Warren de la Rue.

We had what I believe would generally be called a fair passage through the Bay of Biscay, but I was terribly ill. I remember thinking at the time that nothing I could see on my journey, and no success of the expedition, could possibly compensate me for what I then suffered. As we entered Gibraltar I was just getting a little better, though I was too weak to go on shore, but the few hours' rest in the harbour gave me a fresh start, and I enjoyed the sail from Gibraltar to Malta, although the day preceding our entry into that harbour was very stormy. We shipped quantities of water, and I felt very proud of being the only passenger on deck. To one who was not an expert in navigation the narrow entry into the harbour, in an exceedingly rough sea, seemed very dangerous, and the captain and second officer were very proud of having come in so well.

We stayed a night at Malta, and went to the theatre, but I was chiefly impressed by the noisiness of the town and everybody in it. Nothing worth mentioning happened between Malta and Port Said,

out, passing through the Suez Canal, the screw of the ship struck against a floating buoy, and broke three of its blades. This put us into a most awkward predicament, as it was likely to delay us for several days, another ship having to be telegraphed for from Alexandria. This meant that we should possibly miss our connexion at Point de Galle, and fail to reach Bangkok in time for the eclipse. While at Malta, the following telegram was handed to me by Captain Burne of the *Surat*:

Please tell English eclipse party by *Surat* not to go to Galle but to come direct via Bombay to Calcutta, changing steamers at Suez; ask them to telegraph from Suez what is arranged and the number of their party.

(signed) GOVERNMENT OF INDIA REVENUE DEPT.

This telegram of course referred only to the Indian section of the expedition, the Government of India probably being unacquainted with the general arrangements.

The original plan had been that the Indian party should be picked up in Ceylon by a steamer sent for the purpose from Calcutta, and it became clear to me that the accident to the *Surat* rendered it necessary that this original plan should be adhered to, for it would give me the chance, if necessary, of joining the Indian expedition. I therefore telegraphed to the Government of India to the effect that it was impossible for us to separate at Suez, and that they must send the steamer, as previously arranged, to Galle. Meldola was very angry with me at the time, saying that he was in charge of the Indian portion, and must obey orders received from the Government of India, but I pointed out that by the terms

of Stokes' letter I was in charge of the whole expedition as long as they remained together. I therefore told the officers of the *Surat* not to deliver any of the instruments without my instructions.

As nothing could be done until it was known when another steamer could be got ready, we thought we might as well make use of our time to see something of the country round Suez. The greater portion of the passengers consequently started on Saturday, the 27th February, for a short expedition to Cairo, but I did not think it was safe to be away for a night, as the captain refused to fix any time at which he would be ready to start. We therefore formed a small party to go by boat and on camels to the well-known oasis of the desert called 'Moses' Well'. It was interesting in many ways, both as being my first experience of the desert and for the sake of the ride. There were not enough camels to go round, and each camel had to carry two persons. Moses' Well has since acquired a melancholy interest for me, as it was starting from there, and not far from it, that my friend Edward Henry Palmer, the great orientalist, was murdered in the year 1882.

Next day (Sunday) the S.S. *Baroda* was seen steaming down the canal about midday, and soon came to anchor ready to carry us onwards. I spent all the afternoon in the baggage-room, picking out our fifty cases, and it was only as a special favour that the captain would wait for their transhipment. Most of the cases were comparatively light, but the siderostat was packed in a body, and weighed half a ton. I was a little nervous, wondering how it would

be got across from one steamer to the other, but four Arabs, each putting one corner on his shoulder, did not seem to think much of the weight. By eight o'clock in the evening we were on the way to Ceylon.

It was in the Indian Ocean that I first saw the green colour of the first spark of the rising sun. I had never heard of that phenomenon, in fact I believe there were very few records of it. There was some discussion about it some years later. The explanation is fairly obvious. The image of the sun is lifted up by atmospheric refraction and, that refraction being greater for the blue and violet rays, the first spark of the rising and the last spark of the setting sun ought to be fringed with a bluish colour. I saw this effect morning after morning, and, less brilliantly, at sunset.

I expected much from the Southern Cross, but found it intensely disappointing. Altogether the southern constellations seem to me to be very uninteresting.

A few scientific instruments which were handy were unpacked at the beginning of the journey, and I took some observations on the relative amounts of red and violet in the spectrum of the sky at different times of the day. No particular interest attaches to these observations.

The casual remarks of the ordinary passenger about scientific matters, though often amusing at the time, are generally not worth recording, but the following deserves to be mentioned:

A man who introduced himself as being fond of science and a regular attendant at Prof. Tyndall's lectures, after having carefully inspected the spectroscope I had been observing with, remarked:

‘Of course your prisms are all achromatic’. He no doubt had heard a good deal about the necessity and difficulty of making the object-glasses of a telescope achromatic, so as to give colourless images, and he had formed a general idea that this would hold for all optical appliances, including prisms, the whole object of which is to be chromatic.

We arrived at Point de Galle at seven in the morning of the 16th March. It was a pleasure to see green hills again after the monotonous sands of Suez and the arid rocks of Aden. I went on shore in one of the native catamarans, which require an outrigger to keep them from upsetting, and had to make the necessary arrangements for transshipping our goods on board the *Peru*, which left at noon on the same day. The *Peru*, a large and comfortable boat with a good cook, was a pleasant change after the small and overcrowded *Baroda*. After six days’ journey against a head wind, we arrived at Penang twenty-four hours late. As we were going to stay the greater part of the day, there was time to see the chiefsight of the neighbourhood, ‘The Great Waterfall’. Penang is a beautiful island separated from the mainland by the channel which forms the harbour. Having gone on shore, Lott and I joined in taking a native vehicle, and much enjoyed the drive over a good road, through beautiful scenery, past gardens full of palms and other tropical trees. In starting the car, the Malay driver runs along by the side of the horses until he has hurried them on to full speed, and then jumps into the car. The European eye is also much struck by the brilliant colours of the inscriptions over the Chinese shops. To reach the

waterfall, one has to walk uphill a certain distance. The view from the top over the sea is very striking.

An English officer whom we met at the falls proposed to try ascending the mountain at the back of the falls. Lott and I joined him, and thereby narrowly escaped missing the steamer. The ascent through the jungle was comparatively easy, although the hill was steep and the footing so bad that it was chiefly a matter of pulling oneself up by the arms. We did not quite reach the top, as time was running short, and on turning back found that our difficulties had only begun. We lost the way by which we had descended, and found ourselves on a very steep hillside on which it was impossible to gain a footing without holding on to a tree, and with a number of loose stones lying about, which were so easily dislodged as to be a serious danger to the party. We soon got separated, and each had to find his way by himself. After a descent which chiefly consisted in limbing down from tree to tree and stretching out to reach the top of the next below, I found myself by the side of the river, considerably below the point from which we had started. Here I met my two companions, but it was only to separate again. They referred to cross the river by means of a tree lying across it, and to mount up to the top of the waterfall, where they could find the path; I thought it best to descend and cross by a bridge which I had noticed in the morning. After a few unsuccessful attempts, I at last found myself about twenty feet above the bridge but separated from it by a perpendicular rock, down which there was no possibility of descending. By that time I had become thoroughly nervous of not

reaching the steamer before its departure; but there was no help for it, I had to ascend again, and, making a large detour, finally reached the bridge in safety. Meeting a native by the side of a hut, I tried to make myself understood by him, enquiring whether he had seen anything of my companions. Not getting an answer which I could understand, I asked him to go up to the top of the waterfall to look for them. He asked for some money, which seemed encouraging, but he took the money without going. Finally, after vain attempts to make them hear my shouting, I saw them, much to my relief, descending the hill. We were safe now as far as time was concerned, and soon reached our car and the steamer.

We arrived in Singapore early on Tuesday the 3rd March. I had expected to find there a gunboat ready to take us to Bangkok. I had in fact understood that everything had been arranged to that effect; but there obviously was a hitch somewhere. To clear it up, the P. & O. agent took me on board H.M.S. *Hart* to make enquiries, and I was there informed that H.M.S. *Charybdis*, which was to have taken us, had been suddenly despatched to Hong Kong, but that the captain of H.M.S. *Lapwing* had volunteered to take us instead. All this was not very satisfactory, and I decided to call on the Governor, Sir Andrew Clarke, at Government House, which was situated about two miles from the town in a beautiful garden. Sir Andrew Clarke received us in the kindest way, but I could not then quite make out what had happened. From what I subsequently heard, it was a matter of jealousy between the naval and civil authorities, the request to put a gunboat at

our disposal having been sent by the British Foreign Office to the Governor, instead of being made to the Admiralty, who would have transmitted it to the Admiral commanding the Chinese Squadron. The result was that when the commander of the *Charybdis* declared his desire to take the expedition to Bangkok, the Admiral ordered him off to Hong Kong. All this I gathered from more or less veiled remarks, but it does not sound unlikely. The fact remains that we were left in the lurch. Sir Andrew Clarke advised us to take our passage in a merchant steamer which was going to leave Singapore the same evening, and promised to do his best to have a gunboat despatched as soon as possible. This was important, for we really depended on the crew to help us, especially in the work of mounting the instruments, for which men with a knowledge of joinery and locksmith's work were sure to be required. He gave me a letter of introduction to Major McNair, who was acquainted with Siam, and to the Master Attendant, and also sent one of his servants to act as a guide during our stay. This man, who stood at the back of our car in his white dress and red and gold belt, took his orders not to leave us very literally. He stuck to my heels wherever I went during the day, and finally I could only get rid of him by writing a letter to the Governor and sending him back with it. Major McNair proved very useful in giving us letters of introduction to various important personages in Bangkok, and as for the Master Attendant, I do not know what we should have done without him. The *Peru* and the *Kromah-tah* were lying in different harbours, and the instru-

ments had to be transhipped. As no steam-launch could be found, we had to get half a dozen carts, and ultimately the cases were put safely on board the steamer that was to take us to Siam. I had also an introduction to Mr. Geiger, Reuter's agent at Singapore, and arranged with him about the telegrams that had to be sent home after the eclipse. There was at that time no cable to Bangkok, so Geiger had in the first instance to be communicated with by letter. I had refused an invitation to dine with Sir Andrew Clarke because the *Kromahtah* intended to leave during the evening, and I did not realize then that, though the captain was English, he had resided sufficiently long in Bangkok to lose all notions of punctuality, so that the evening might mean anything between midnight and the following midday. The *Kromahtah* was fairly comfortable, with only two passengers besides ourselves, and large cabins with regular beds instead of the P. & O. bunks. Cockroaches were plentiful, but one soon became accustomed to them.

Our journey was a slow one; an accident to the engine, causing a delay of several hours, made us miss high water, which is necessary for crossing the bar of the Meinam (Mother of Waters) river. We managed to scrape across at 7 o'clock in the evening on Sunday, 28th March, and after steaming up the river, anchored near the southern end of Bangkok at half-past eleven at night—thus concluding a sea-journey which had lasted forty-five days.

We had made up our minds to pass the night on board, but at midnight boats came down with a Mr. Bietje, a young man of Dutch origin, who was

it by a Mr. Alabaster to take us with our personal baggage to the house of the latter. Alabaster then occupied a peculiar position in Bangkok. He was finally attached to the British Consulate, but his feelings were too friendly to the Siamese to please the Consul, and some of his actions while in charge of the Consulate during the Consul's temporary absence were disapproved of. His position then becoming untenable, he had been offered another and better post by the Colonial Office but had refused. Ultimately he entered the Siamese service as confidential adviser to the King.

During the whole time we were in Siam we were the guests of the King, dining off Royal plate and drinking out of glass which had the Royal arms engraved upon it, but the King had asked Alabaster to look after us and lodge us at his house. It is late before we went to bed and the first night on shore in the tropics is not easily forgotten. Sleeping under a mosquito net, which seems to stop all circulation of air, always gives an oppressive feeling, and, personally, unless the mosquitoes are very bad and numerous, I have always preferred to risk a few bites and to do without the net. Then there is the grating noise of the punkah, which is peculiarly grating, though it is not the only or the loudest sound. The whole air seems alive with all kinds of cries. There is in the first place the tokay, a big lizard which runs over the walls and produces a loud noise resembling the cry of a child. There were three or four of them in the room. Outside, the bellowing of the bullfrog overpowers the sharper noises of the other all insects.

There was little sleep to be got and I was up again at 6 o'clock in the morning. My instructions were not to pay any duty calls on the King or his ministers before the eclipse, but to go straight out to the observatory. Unfortunately these instructions did not take into account the obvious fact that no steamer would be available until the duty calls had been paid. I had to ignore this like so many other instructions, and put myself altogether into the hands of Alabaster, who fully realized the importance of starting work as soon as possible. He at once sent a note to the King's private secretary to announce our arrival, and we started on a round of visits after *chota hazri*. Bangkok is entirely built along the river so that communication is only possible by water. We found the King's private secretary, Phya Bashakarawongse, who talked fluent English, on the point of starting to call upon us. He asked us numerous questions which we had to answer many times that day. 'Why were we so late?' 'When did we want to go to the observatory?' 'What were we going to do during the eclipse?' etc. Other visits were to the Prime Minister, and to the Kromahtah. The latter, who acted as Foreign Minister, gave us breakfast. He made a great point and special favour of his promise to send his own nephew to make all the arrangements to take us out to the observatory, and look after us while there.

In the early afternoon, we paid our visit to the King. We were received in the Palace grounds by the private secretary and Prince Kap, the head of the army, a nice-looking young man in cavalry uniform, who, I believe, died the following year of

cholera. He took us to the King's room, where we found His Majesty sitting on a couch waiting for us. After the necessary introductions, we all sat round a table. The conversation was at first formal, the King expressing his pleasure at seeing us, and adding that his invitation to us was sent out of special regard to his late father, who had taken such an interest in astronomy. Alabaster acted as interpreter, and I nearly got myself into hot water. I did not know what to say in answer to one of the King's questions, so I asked Alabaster to give him the answer which seemed to him most suitable. I heard afterwards that the King understood English perfectly well; in fact, in all subsequent interviews he spoke English to me. However His Majesty took no notice of, or at any rate no offence at, my awkwardness.

In the meantime Alabaster had received a letter from the Kromahtah to the effect that, after consideration, he did not think he could now send his nephew. This letter was shown to the King, but he returned it laughingly without any remark. This was the beginning of a good deal of annoying correspondence which continued during the rest of the day. The Kromahtah's ostensible reason was, that as M. Janssen, the French astronomer, was already in the country for the purpose of observing the eclipse, and as he had not sent his nephew with the French astronomer, he was afraid of arousing international jealousy by sending his nephew with us. The real reason was a personal squabble between the Prime Minister and the Kromahtah, each of whom claimed to have the first right to assist us. The result was a deadlock, with a very serious danger of another de-

lay, because although it mattered very little whose nephew went with us, no preparation could be made for transshipping our luggage until this question of etiquette was settled. The matter was only decided late in the evening by a letter from the King to Alabaster, stating that as the Minister of Foreign Affairs refused to put us in charge of an officer of his department, the King would send an officer of his own. He had consequently ordered one of the princes, Mom-Dang by name, to accompany us, who afterwards proved of very great help.

After dinner, a Siamese scientific society, simply called 'The Society', met in Alabaster's house. I was asked to give a lecture on the eclipse. It was a curious experience. I had three interpreters, Alabaster, the King's private secretary, and another. After every few words, I was stopped by one of the interpreters, generally in the middle of a sentence, and had to wait while my words were being translated, sometimes by one, sometimes by another, and sometimes by all three at once. It was not always easy after that to find the thread again. I could not help once or twice laughing out loud, when I thought of the ridiculous position in which I was placed. I could have done nothing better if I had specially wished to ingratiate myself with the Siamese. They are very fond of laughing, and everybody who laughs is their friend. They listened very attentively, and there was a good deal of moving and seconding of votes of thanks at the end. There was a social side of the Society, to which I was introduced after the lecture. Some new members had to be elected. One of the great jokes of the Society consisted in black-

balling, and shouts of laughter always accompanied the announcement that a candidate had been black-balled. Afterwards we played billiards. I had a Siamese as partner, who really played exceedingly well. Besides the members, there was an audience consisting of all the boatmen belonging to the members present. These boatmen do not understand a word of English, but nevertheless, after a particularly nice shot of mine, I heard a chorus of 'Fluke!' from the corner where they stood. There was the usual laughter after that, and we went on with our game.

Next morning by nine o'clock, all our instruments were on board the Royal Siamese Steamer which rejoiced in the name of the 'Northern Siam Enjoying'. The Kromahtah was still sulking, but the Prime Minister was on board to see us off. The boat was old and out of order, and we suffered from constant delays. The observatory had been prepared for us along the shore at the exact spot where the central line cut the coast. This rendered it necessary for us to steam down the river, cross the bar and find the spot, where a beacon had been erected. We had to stop at Packnam for a pilot who kept us waiting for an hour, with the usual result of missing the tide. We crossed the bar at 7 p.m. and there was no chance of reaching the observatory the same evening, as we had intended. No arrangement had been made for sleeping on board, so we had to settle down as best we could amongst the cases of instruments. The sea was heavy and we had to anchor about 3 o'clock in the morning for fear of missing the observatory. Starting again at 7 a.m., and after vain

attempts to see the beacon, we got hold of a fisherman, who acted as pilot. We soon were on shore. There was no proper landing-place for the instruments, and the sea was so rough that it was quite impossible to lower the cases into the only available boat. It was wonderful, however, what the Siamese had done to prepare for our arrival and that of Janssen.

They had been informed by the secretary of the Royal Society that the line of totality would cut the coast at latitude $13^{\circ} 0' 30''$ N. and longitude $100^{\circ} 2' 10''$ E. The coast at that spot was formed by a line of palms immediately backed by a dense jungle, and there was no drinking-water within several miles. The jungle had been cut down, four or five comfortable dwelling-houses had been erected, and arrangements made to supply us with good drinking-water. A whole native village had risen up in close vicinity to the dwelling-houses. These natives were serving their time in doing work for the Government, which, for the poorer classes, takes the place of paying taxes, or at any rate did so at that time. Whoever was too poor to pay gave up two or three weeks in the year, or whatever the time fixed upon might be, to perform the labour imposed upon him by Government. One of the dwelling-houses had been reserved for us, and consisted of a number of rooms well raised above the ground. A large hall served as dining-room, and there were good arrangements for storing provisions and bathroom accommodation.

Similar accommodation had been provided for M. Janssen, who had arrived before us, and a large

bungalow accommodated the Ex-Regent of Siam, who was on the spot during the whole of the preparations for the eclipse, together with a number of wives and elephants. The building had been carried out under the orders of Captain Loftus, an Englishman engaged for surveying work by the Siamese Government. He had also made provision for an extensive platform which was to accommodate our instruments. This platform was covered by a high roof formed chiefly of dried palm leaves, which served as a protection against the sun and against showers of rain, which were not impossible at that time of the year. On either side of this platform, there was a hut covered as densely as possible for photographic purposes. The instruments were finally landed about 10 a.m. on the day after our arrival. This was the 1st April. The transshipment and carrying of the siderostat gave considerable trouble. What was done by four Arabs at Suez could only be accomplished by fifty Siamese.

We had only five days left to get the instruments into adjustment and to prepare for the eclipse, and anyone who has taken part in an astronomical expedition will know what that means. Fortunately the climate was such that, although the temperature was seldom below 90° in the shade in the middle of the day, we could work right through, and generally spent twelve hours on our work—once even as much as eighteen. The first thing to be done was to secure a good foundation for the equatorial telescope. It had only a narrow base, which would not allow it to stand firmly by itself. It was therefore placed on a brick foundation that was built under the wooden

platform. A hole was made in the platform and the telescope firmly wedged into that hole. This, of course, had the disadvantage that anyone walking across the platform produced a slight vibration of the instrument; but for spectroscopic purposes this was not of material importance, and it could easily be arranged that during the actual exposures no one should walk about.

When the latitude adjustment had to be made, a serious difficulty arose. The instrument was intended to be secured by four screws, but, when used at the low latitude at which we were, two of these fell outside the supporting stand, so that the whole weight had to be supported by two; of these, one had been broken in the journey, and the other did not fit without an additional washer. A few broken steel pens could be made to serve instead of a washer, and the whole instrument had to hang on this one screw until the *Lapwing* arrived, two days before the eclipse. The spectroscopes also gave an infinite amount of trouble. The collimator tubes were too long and had to be cut down before the slits could be placed in the focal plane of the lenses. There was also no means of turning the slit round in its own plane, or of rotating the collimator tube, and the makers had actually placed the slit at right angles to the refracting edge of the prism. All these defects are of little importance if one is provided with a proper workshop, or a skilled mechanic, but we had absolutely no suitable tools, and none of us were trained for that kind of work. The artificer of the *Lapwing* made short work of the difficulties, but until it was actually in sight I did not

know whether any boat had left Singapore, and I had also given up hope of getting help.

Some of the defects of the spectroscopes were not so easily dealt with. The quartz prisms were streaked and gave me very imperfect images. The backs of the cameras could not be inclined to the axes, so that only a very small portion of the spectrum could be in focus at once. I tried to get as good a focus as possible for the H and K lines, but was very much troubled by the want of definition, and it was some time before I found out the causes.

The siderostat was beautifully packed, and only required latitude adjustment, but a curious incident occurred which might have puzzled me very much had I not been present during the packing. When the clockwork was first set going, and the image of the sun watched in the slit plate of the spectroscope, it was found that the sun seemed to move much more quickly off the slit than when the clock was stopped, and this was quickly traced to the fact that the mirror turned the wrong way. Now just before the instrument was put into the case in London, I was standing by with two or three men, and we noticed a curious little mechanical device, the object of which we could not at first fathom; but one of the onlookers—I believe it was Colonel Strange—remarked that it was an arrangement for reversing the rotation of the mirror, so that the instrument could be used in both hemispheres. As a matter of fact, the makers had adjusted it for the southern hemisphere, and it was easy to set it right. It was curious that a similar but more serious difficulty cropped up at the West Indian eclipse in 1886, when one of the observers

was provided with a photoheliograph, used in a southern latitude, for the Transit of Venus. The telescope, naturally, moved the wrong way round, and there was then no means of reversing the motion.

All these little troubles delayed us, and of course, at the best, the adjustment of an equatorial telescope and a siderostat takes time. We had no doubt plenty of willing helpers, but there was no one besides myself who had any knowledge of astronomy or knew how to adjust a spectroscope. Lott was a most useful, energetic and willing assistant, but he could not be expected to deal with any difficulties. Beasley was fully occupied with getting his photographic chemicals into order, and was not in over-strong health. Captain Loftus was invaluable in taking the sextant observations, and getting the natives to work. His little son, a child of about ten, was the general interpreter, knowing Siamese, Malay and English. We had in addition a few Europeans from Bangkok, some of whom volunteered to help during the eclipse, while others looked after the provisioning or housekeeping. The servants were Chinamen. They did well, but were very independent. I remember once, during dinner, that one of the Europeans in Siamese employ, who was put in charge of the domestic arrangements, threatened to beat one of the Chinese waiters. The Chinaman very calmly turned towards him and said, 'No, you won't do that'.

The *Lapwing* arrived on the 4th April, but, the coast being rather unsafe, the commander, Sir William Wiseman, had to anchor a good distance away, so that communication was not easy. A detach-

ment of bluejackets and two officers remained permanently on shore. Preparations now went forward a little more briskly. The invaluable aid of the artificer has already been mentioned, and the two officers, the Hon. H. N. Shore and Mr. A. L. Murray, gave good assistance, but the day before the eclipse matters seemed to be altogether in a hopeless condition. The rehearsals for the eclipse work had to be started before the instruments were properly adjusted. It was a cruel position for a young man to be placed in who knew, or at any rate felt convinced, that failure would mean ruin of his future career. I could not help sitting down and having a good cry, but Captain Loftus soon cheered me up again, and I started on the final preparations, though I almost hoped that the weather, which was a little threatening, would turn bad and relieve me of all responsibility.

A day or two before the eclipse, I was pleasantly surprised by the arrival of Mr. Eschke, a German artist and expert photographer, who had assisted at one of the Transit of Venus expeditions in the previous December and had come on to Bangkok with the intention of seeing something of the eclipse. He was sent out to our station at Chulai Point and volunteered assistance, which was gladly accepted.

The morning of the eclipse broke absolutely cloudless. A long line of Siamese were placed to form a cordon round the observatory. This was necessary, especially in view of the Ex-Regent's elephants, who might easily have got frightened by the darkness of the eclipse. It is not necessary here to give all the details of the arrangements made. They were rather more complicated than those needed

at present, owing to the wet-plate process, which did not allow plates to be prepared beforehand, and which necessitated immediate development. Eschke, in one of the dark-rooms, prepared the plates; Beasley, in the other one, developed them. The bluejackets had been easily trained to carry the slides to and from the instruments. Lieut. Murray and Mr. Pattison called out time. Beasley fortunately possessed a fine camera with a lens capable of lateral motion. As I knew the danger of failure with the spectroscopic cameras, I was glad to make use of this camera for taking pictures of the corona, and though the images were small, they proved very useful. I was going to give the signals for beginning and end of totality, change the slides of the prismatic camera and equatorial telescope, and keep a general supervision to see that the programme was strictly carried out. Everything went without a hitch, except that, a little startled by the fact that the corona burst out on the dark side of the moon several seconds before the last spark of the sun had disappeared, I rather lost count and gave the signal for beginning of totality too late, but probably only by two or three seconds.

The corona was different from what I had expected from the description. Instead of showing a soft silvery light, it struck me as being bright, almost dazzling. The appearance seemed something like the false rays you see when you look towards the sun, and I could well understand that some of the early observers thought that the corona had no normal existence but was due to irregular refraction in our atmosphere.

When the sun burst out once more, a feeling of relief came over me that all the excitement was over, and at the same time a feeling of intense disappointment, a kind of presentiment of failure, due no doubt to the sudden relaxation of the nervous strain. Prof. C. A. Young of Princeton, U.S.A., who had considerable experience of eclipse work, once told me that a peculiar feeling always came over him within the few minutes following totality, which he did not have on any other occasion, and which he could only describe as the sensation of realizing that he was a mean dog.

One incident is worth mentioning as showing that if one has made up one's mind to pay attention to a certain succession of events, one is deaf and blind to anything else. I had fully thought out what I was going to do during the eclipse. Amongst other things, I was going to watch the sailors carrying the slides to and from, not only my own instrument, but also that of Lott, who looked after the siderostat and reflector. I am quite convinced that I should have noticed if anything had been done differently from what was arranged in the programme, but, on the other hand, I did not notice a disturbance for which I was not prepared, and which might have proved serious. The Ex-Regent had a little 3" telescope, through which he was anxious to watch the corona. He had a European secretary, who was expected to point the telescope, and was very anxious before the eclipse to have the instrument housed in our observatory. I was a little nervous about this, and, after some trouble, persuaded him that he would be more his own master

if he placed his telescope on a special table a few yards away. During totality, I was afterwards informed, the poor old gentleman came rushing into our observatory, tearing his hair because his secretary could not be found. The latter gentleman was afterwards discovered soundly asleep, he not only having missed the whole eclipse, but also having prevented his master from getting a sight of the corona.

The results of the observations were as good as the instruments would permit. We now know that no wet plates could have given an impression of the spectrum of the corona, for our present films, which are at least sixty times as sensitive, require at least a minute's exposure. If the instrumental appliances had been more favourable, we should, however, probably have obtained some indication of the continuous spectrum close to the sun, with possibly a few chromospheric lines. The photographic camera used in connexion with the large reflector and siderostat had a focal length of 3 feet with a comparatively small lens. The luminosity of the image was therefore hopelessly small. The other camera, attached to the equatorial telescope, had a more reasonable focal length, and the dimensions generally were not unlike those of the instrument which proved successful in the eclipse of 1882, when, however, very sensitive dry plates were used. The photographs obtained by the prismatic camera gave results of importance, though the angle of the prism might with advantage have been larger. There is, of course, always a difficulty in identifying the origin of the image obtained with that instrument. The hydrogen lines of the chromosphere and prominences always appear and serve as

fiducial marks. I spotted the big F and G lines pretty quickly, but was a good deal puzzled by exceedingly strong images of the prominences more towards the violet. I had no means of accurate measurement with me, and thought at the time that these strong images were due to the H lines, but on reaching home the wave-length was found to be decidedly smaller than that corresponding to the violet hydrogen. The exceedingly small dispersion did not allow an accurate determination, but I came to the conclusion that the strong prominence vibration was due to calcium, the H and K lines not being separated. This result has been fully confirmed in subsequent eclipses, but the importance of calcium in the chromosphere and prominences was first proved in the Siamese eclipse, though certain eye observations of C. A. Young's might have allowed us to anticipate the conclusion.

The complete results of the expedition are printed in the *Philosophical Transactions of the Royal Society*¹, in a joint paper by Sir Norman Lockyer and myself. To Lockyer belongs the merit of designing the prismatic camera. I cannot conclude this account of the eclipse without reference to the efficient and willing help given by Sir William Wiseman, the commander of H.M.S. *Lapwing*, and his subordinates. Without their invaluable assistance it would have been almost impossible to surmount the difficulties with which we had been faced.

After the eclipse, I had hoped for a day's rest, but the Governor of Petchaburi, who was in immediate charge of the Siamese labourers, asked us

¹Vol. clxix, pp. 139-154.

to take down the instruments as soon as possible, so as to have everything packed up by the 11th April. On that day the great Siamese festival corresponding to our Easter was to begin, during which no Siamese can be made to work. The Governor was exceedingly polite, and even offered to try to force some of the men to go on with their work if necessary, though that, he said, would probably lead to his getting into trouble at headquarters. I, of course, fell in with his wish, though it involved very hard work for us, especially as the instructions of the Royal Society forced us to take a number of copies of the photographs obtained, in case of accidents to the originals.

I have not, so far, mentioned anything about M. Janssen's observations. He was on the spot before our arrival, but I was so busy during the whole of our stay that I saw very little of him. He had a reflecting telescope of short focal length, and a spectroscope through which he made eye observations. By an ingenious arrangement he could look at the direct image of the corona without shifting his head, the eye-piece for the latter purpose being placed against one eye while the other eye was at the end of the spectroscope. He was thus independent of any assistant, could point his own telescope, and knew exactly what position of the corona was on the slit. I do not think, however, that he obtained any results of importance during this eclipse.

M. Janssen of course acquired a great reputation through his discovery of the method of observing the spectrum of the chromosphere without an eclipse. The discovery was made simultaneously by Norman

Lockyer, and both astronomers at once acquired a well-deserved celebrity, the French Academy striking a special medal in their honour. This forms a good example of the error made, especially by young men of science, when they are so terribly afraid that someone else should work at the same subject as they do, and bring out the same result simultaneously. So far from duplication of discovery taking away from the merit of the work in the eyes of the world, it adds to it by attracting attention, and increasing the confidence in the result. One need only point to the discovery of Neptune by Adams and Leverrier, to the early history of the theory of the conservation of energy, and to the above example to show the fallacy of the common idea.

Janssen was a man of dramatic instincts, and a good deal of his published work has something theatrical about it. During the siege of Paris, while shut up in the capital, he was anxious to observe the total eclipse of the sun which took place at the end of 1870, the line of totality crossing Sicily. English astronomers took a great deal of trouble at the time to obtain special permission from the German military authorities for Janssen to pass through their lines. This they succeeded in doing; but when Janssen received his permit, he refused to make use of it, preferring to leave Paris in a balloon, and thus unnecessarily risked his instruments and his life, but gained the applause of newspaper correspondents, who, of course, knew nothing of the more safe exit that was available.

I heard afterwards that the fact of my being of German origin caused Janssen to look upon our

expedition with a certain amount of disfavour, though I cannot say that he showed it at the time. He encouraged me to take the small-sized photographs of the corona, and suggested varying the exposure as much as possible so as to decide whether there was a definite outline to the corona, or whether it gradually faded into space.

We were always on the most pleasant terms with the Siamese, but Janssen did not seem to get on with them and took no pains to adapt himself to their little peculiarities. He was very indignant at the Siamese request that the packing should be hurried up, and though he had only one large instrument, and had brought two French sailors to assist him, he spent the days succeeding the eclipse in going out shooting. On the 11th April we were ready to start, and, on taking leave of Janssen early in the morning, I reminded him of the fact that the Governor had warned us that the Siamese holidays had begun. He ridiculed the idea and said he was staying on purpose to show the Governor that a few small coins would quickly get over that difficulty. I met Janssen next day in Petchaburi, and on expressing surprise at seeing him, he commented indignantly on the fact that in spite of all his generous offers of money, he could not get his breakfast cooked. He had to pack up in a hurry, and, I believe, travelled by land while his instruments were shipped on board the *Impératrice*, a steamer provided by the Siamese, who, no doubt, foresaw what was going to happen.

Petchaburi lies up the River Mainam-Faichaburi, which is not navigable except for rowing-boats, and we expected one to be waiting for us at its mouth. To

get at it, we had to cross a bar, but, with our usual bad luck, arrived at low water. Our boat had smashed to pieces on the beach off Chulai Point, and, though we signalled in the hope of attracting attention, we were unsuccessful. Neither whistle nor gunshots brought any of the fishing-boats that were in sight to our assistance, but the *Impératrice*, which had arrived and anchored a little way off, finally understood us, and, as she only drew four feet of water, we went on board her in the hope of getting into the river. The way a Siamese boat gets across a bar is to start a little distance off, get up steam, and having acquired full speed, simply make for the obstacle in the hope of scraping through the mud. This is not generally successful at the first attempt, and one never knows whether one will not finally get stuck altogether; but after three running leaps, as it were, the method answered on the present occasion. We found our boat, but it was getting dark. It took us two or three hours to get to Petchaburi. The river was narrow in places and wooded on both banks. While lying down in the boat and gliding along through the silent darkness, I imagined myself taking part in one of Fenimore Cooper's Red Indian stories, of which I have always been very fond. The romance was rather spoilt by the discomfort of being crowded together in a narrow space, in which the leg of one person had to serve as a pillow for his neighbour. We stopped opposite the Prime Minister's house, where we were to lodge.

The court moves for the summer to Petchaburi, which has a fine palace as well as houses for the principal members of the Government. Our host, the

Governor of Petchaburi, called on us early next morning and we began two days of sightseeing. The most interesting of the sights were the sacred caves. Fifty-eight steps led down to the first landing. To the right, in a niche formed by nature and surrounded by stalactites, is an image of Buddha, with two images of smaller size and importance on either side; to the right, a little farther on and inside the cave, stands a throne made of wood covered with gilded plates. Over it is a canopy supported by four pillars. The throne, $5\frac{1}{2}$ feet long by $2\frac{1}{2}$ feet wide, is reputed to be the size of Buddha's foot, and he is supposed to come and stand on it at night. Five depressions at one end indicate the position and size of his toes. Beside the throne are more images, and a stalagmite supports a plaster elephant of large size. A little higher up, in niches, two images, formed to resemble skeletons, represent wicked people come to life again in this form. Another recumbent figure represents a Siamese ghost.

This first cave is about 80 feet long, and opposite the entrance are twenty-two steps leading down to the second and principal cave, which is about 200 feet long by 140 feet broad, and very impressive. High up in the roof a small circular opening admits the daylight, which, dimmed by the layer of leaves from overhanging trees outside, is just sufficient to allow the objects in the cave to be distinguished. The most striking of these is the large sleeping image of Buddha, 50 feet long. There are other images of Buddha, of various sizes, all round the walls of the cave, and two kneeling images of goddesses in the body of the cave, resting on stalagmites. On one

portion of the wall alone I counted seventy images. The mysterious effect is increased by various recesses formed into temples. I was naturally anxious to secure a memento, but I did not venture to ask for one or to desecrate the cave by taking anything away. The Vice-Governor, however, who was with us, and who guessed my covetousness, took a small gilt wooden image of Buddha and gave it me, asking me, however, not to carry it openly through the streets. I have carefully preserved this little relic.

Another interesting expedition was to the settlement of Laos, a part of Siam lying to the north. The inhabitants—a fine race of men and women—inhabit rather curiously constructed huts, which they did not seem to mind our entering and inspecting.

We had an odd experience on the second night of our stay. The Governor entertained us at dinner, and on entering the dining-room asked me to take the head of the table and to arrange the other seats. I felt rather uncomfortable, because I knew the extreme sensitiveness to etiquette of all Eastern races, and as all the guests except the three members of the expedition were Siamese, whose official positions I was unacquainted with, I ran the risk of making a number of enemies. I think on these occasions it is best to take the bull by the horns. I made them a little speech in English, which was at once translated into Siamese, in which I asked the Governor to sit on my right, and suggested that the rest of the company would probably prefer to choose their own seats. They very good-naturedly fell in with this idea and the dinner proceeded.

Of the meal I remember little except that English

and Siamese dishes alternated, and that our host was very curious to have my opinion on all the native delicacies. Only one of these has remained in my memory; it was a bamboo salad, which was nicer than would be expected from the name, and must have been made of very young and tender plants. The after-dinner speeches call for no comment except that of the Governor, which was carefully prepared and written out on rice-paper, and handed to him by one of the servants who came crouching into the room. Almost the first act of the King after he ascended the throne had been to forbid kneeling and the peculiar posture adopted by the servant was intended to convey the impression of kneeling without disobeying the King's edict. I asked for permission to keep the written document, of which the following is a translation:

I have received with much pleasure the good wishes for my health which your professors and members of the mission have expressed, and I think that every one will join with me in offering our welcome to your professors whom your Government has sent to witness the eclipse of the sun at Chulai Point.

Your professors and members of the mission have conducted themselves in a manner worthy of Queen Victoria and the Government who have sent you, and you have paid your respects to His Siamese Majesty and his Ministers in order to cement the ties of friendship.

May the good relations between our two countries prosper for ever, and may Queen Victoria and the British Government and your professors and members of the mission enjoy long life and prosperity.

In Siam, as in other places, an ignorant population looked upon eclipses as due to an evil spirit, which

had to be driven away by noisy demonstrations. It so happened, however, that the King of Siam who had recently died was interested in astronomy, and is reported to have given a different and somewhat ingenious explanation of the noises without calling upon any supernatural agency. The great noises, he is reported to have said, which are made by my subjects during an eclipse, such as the firing of guns and the beating of drums, are not an effort to frighten away an evil spirit, but a sign of joy of all men that their mathematicians are able to predict the time of such extraordinary events.

The activity of the expedition was approaching its end, as most of its members had to return to their normal duties. Fortunately I had made arrangements which allowed of a longer absence and Alabaster invited me to stay on as his guest. I was free, and glad to accept the invitation. I returned home by a longer route, through India.

XI. FROM SIMLA THROUGH KULU TO KASHMIR (1875)

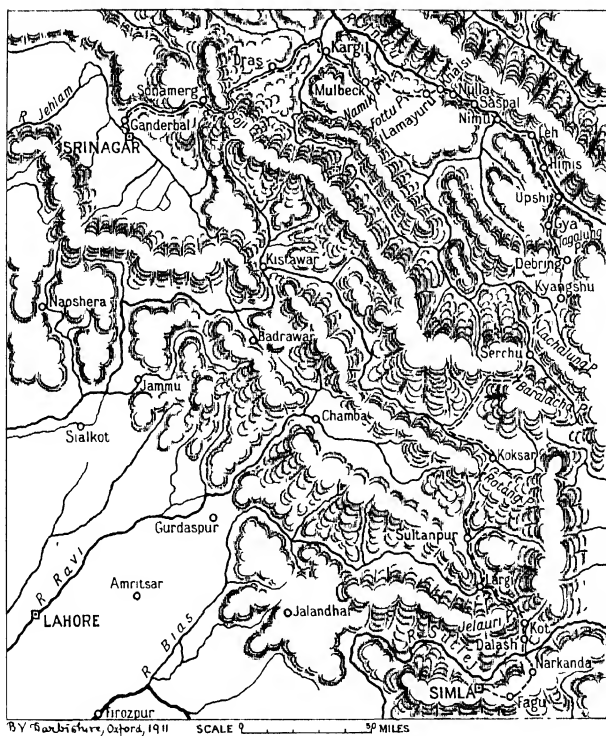
I LANDED in Calcutta some time in May and, after staying a few days with business friends of my father, proceeded to Simla, travelling across the plains just before the monsoon broke and consequently having an unpleasantly hot journey.

During my stay at Simla I attended a reception at Government House, where I again met Sir Andrew Clarke, the Governor of Singapore, who had shown me so much kindness on my journey to Siam. Captain Baring, afterwards Lord Cromer, was at that time private secretary to his uncle, Lord Northbrook, the Viceroy. During the course of the evening he approached me with regard to the establishment of a solar observatory in India, which had been referred by the Home Government to the Government of India, and asked my opinion as to the suitability of Simla for this purpose. As a result of this conversation the following correspondence took place between us.

PRIVATE SECRETARY'S OFFICE,
GOVERNMENT HOUSE,
SIMLA, July 20, 1875.

DEAR MR. SCHUSTER,

I think that you expressed in conversation with me some days ago an opinion that Simla was not a suitable



MAP OF JOURNEY FROM SIMLA TO SRINAGAR
(Route shewn in dotted line)

situation for a solar observatory. Lord Northbrook has directed me to ask you whether such is your opinion, and, if so, whether you have any objection to its being quoted in an official document?

Yours very truly,

E. BARING.

SIMLA, Tuesday, July 20, 1875.

DEAR SIR,

In selecting a station for a solar observatory you have to avoid, as much as possible, rain as well as haze. The objection to Simla is that during about five months out of twelve you cannot make any observations. The European sky in clear weather is just as good as any sky you can get in India.

The great advantage of an observatory in India would be that you have a much greater number of clear days. In my opinion, therefore, a slight haze during part of the year is preferable to several months of rain.

An observatory in which you could take regular photographs of the sun during, say, 300 days of the year would be sure to give most valuable and interesting results within a very short time.

I believe that in the Punjab you will be able to find a place with little haze and little rain.

The advantage of an observatory in India—even in Simla—over any in England, is however, so great that were it a question of erecting an observatory here or not at all, it would be a great pity to give up the idea on account of the rains.

I have no objection to having this opinion quoted.

I shall start to-morrow for the interior and am sorry, therefore, I shall not be able to answer at once any other question you might wish to ask. Any letter addressed to this hotel will, however, be forwarded to me.

Yours truly,

ARTHUR SCHUSTER.

I believe that, as a result of this correspondence, Kodaikanal (in Southern India) was selected as the site of the solar observatory which was opened in 1899.

I had soon become tired of the monotonous life of Simla, especially as the rainy season prevented much out-of-door life; so that when a Captain Webster, whom I had met, suggested my joining him and his brother on a walking tour through the mountains, I gladly accepted the invitation. The idea of tent-life, of a climb over the snowy ranges of the Himalayas, of a journey through the Vale of Kashmir, which was enshrined in so much mystery and romance in one's imagination, made my heart beat with pleasurable anticipations.

Little time could be spared for preparations, as my companions were limited by their leave and wanted to start almost as soon as they had decided on the journey. We arranged that they should go on by slow marches and that I should catch them up either at Matiana or Narkunda, places that could be reached on horseback. This gave me two or three days to prepare a kind of outfit, secure a tent, camp-bedding and provisions. I was lucky to get the loan of a tent and bedstead from Dr. (afterwards Sir Dietrich) Brandis,¹ who was also good enough to offer me a pony. The bedstead was a light wooden one which could easily be taken to pieces, but it may appear rather an excess of luxury to have taken a bedstead at all. I found it, however, well worth the extra weight—in fact quite a necessity

¹Sir Dietrich Brandis, K.C.I.E., F.R.S. (1824-1907), was the first Inspector-General of Forests to the Government of India.

when crossing the belt of the rainy season. I was similarly glad to have followed Dr. Brandis' advice not to stint myself with blankets, so as to be able to camp out in the open, even though the temperature might be below freezing-point. I could get pretty well all I wanted in Simla, except an aneroid barometer. I bought a very clumsy one, which very soon broke and had to be thrown away. The only instruments I carried were a dry and wet bulb thermometer and a little pocket spectroscope.

I was ready to start on Wednesday, the 21st July, but the rain came down in such torrents during the whole of that day that I had to put off my departure. Next morning the rain lessened, and it cleared up during the day. I made a start at 9 a.m. and rode as far as Fagu, through country which seemed beautifully wooded, but was for the most part in the clouds. No one who has not travelled through a mountain district during a tropical rainy season can have an idea of the power of water in upheaving the surface of the earth, and cutting through mountains. Waterfalls form and spring out of the hills almost in every direction and in most unexpected places, and frequently splash down on to the path. On such occasions the only possible course for the pedestrian is along the path itself, so that he begins to doubt whether he has not missed the way and is not travelling in a river-bed.

At Fagu I sent Dr. Brandis' pony home in charge of the sais who had followed me, and from there walked on by way of Theog to Matiana, where I picked up my own pony, which I had sent on a day or two previously. The road to Narkunda is fairly

level, so that I could canter on pretty quickly for a distance of two miles. This was necessary if I wanted to reach Narkunda, forty miles from Simla, before nightfall. My pony, which was always obstinate, played me a nasty trick. I was cantering happily along past a pool of water. It suddenly jumped to the side of the path and lowered its head as if to drink; the edge, softened by rain, gave way, and horse and rider slithered down into the pool, which was so deep that only the pony's head was above the water and I was wet through to the waist. I managed to scramble out, but it took me some time to extricate the pony. In fact I had almost given up the attempt when at last I found a place which was not so steep. I had a very uncomfortable ten-mile ride after this, my difficulties being increased by the wet saddle rubbing the pony's back.

Night was rapidly coming on and I had Dr. Brandis' last warning ringing in my ears, 'I must give you one piece of advice: if at any time during your journey you are surprised by the night, don't attempt to push on; whatever place you are in, and whatever the weather may be, stop there and don't try to travel in the dark'.

I had therefore to be prepared to camp out, but did not think so much of this discomfort as of the danger of missing my companions and losing my whole trip, for this was the latest date to which they had promised to wait for me at Narkunda. It was a beautiful evening, and the night was just coming on, when to my great joy and relief, on crossing a ridge, I found myself overlooking the Sutlej valley, with the lights of the bungalow at Narkunda close

by. My friends had given me up and were equally pleased at my arrival.

The bungalow at Narkunda is one of those little one-storied buildings which are erected for the convenience of travellers at certain distances along frequented routes. They generally consist of about half a dozen empty rooms (for every one travels with his own bedding) and a covered passage running along the front of the rooms. The better ones would have a few chairs in various states of dilapidation, and sometimes a man (*chowkidar*) is in charge of the building.¹

Next day, which was a Friday, we hoped to make an early start, but all our luggage had to be packed on mules and it was 9 o'clock before these were ready to leave. We hoped, however, to accomplish the nineteen miles to our next resting-place, Dalash, without much difficulty. We descended six miles to the village of Komarsen, where we were going to breakfast, and here I first became acquainted with one of the difficulties of travelling in a country where there are no inns, a difficulty which only much delay and experience taught us to overcome. We were hungry, and anxious to get on as quickly as possible, yet we had to wait an hour until the mule which had the cooking appliances on his back had picked his way down the steep slopes of the mountain. Then there was the time spent in collecting firewood, in lighting the fires, and in hurrying up the native servants, one of whom acted as cook.

¹The dak bungalows along this route are now much better furnished, but it is still necessary for the traveller to take bedding, though not his bed, with him.

It was three o'clock before we could make a fresh start.

I was struck by the appearance of the villagers; their colour, especially that of the women, was much lighter than that of the natives who dwell round Simla. The upper part of the slope down which our way led was beautifully wooded, and lit up by the brilliant colours of the numerous flowers. As one comes down into the valley, the land becomes more and more stony and barren, and the path almost ceased to be fit for human feet. Though accustomed to walking about the hills in Switzerland, I found the strain, especially on my knees, very considerable, owing to the difficulty of keeping upright on such a steep path covered with loose stones. It is a wonder that our mules ever succeeded in reaching the river in safety. Most of them were ahead of us as we had sent them on, while resting at Komarsen. We reached the Sutlej exhausted and tormented by thirst, yet the water was so dirty and full of grit and stones, besides being tepid, that it was impossible to drink. I tried to filter some through several layers of pocket-handkerchiefs and even blotting-paper, but did not succeed in getting more than a few drops in a tolerably clear condition.

It was intensely hot, and in our miserable condition we could appreciate the name which has been given to this valley—"The valley of the shadow of death". There was a good wooden bridge and, finding a suitable place, I tried to get cool by a bath in the river. This was not free from danger. The river, swollen by recent rains, was so rapid that, though wedged in between rocks, I had to hold on tight.

Down the stream shot large logs which are thrown in by the natives in the upper parts of the valley, and collected at certain places in the plains. The river is thus made a cheap means of conveyance.

It was still intensely hot and close when, at half-past five, we ascended the northern slope of the valley. Still suffering tortures from thirst, we were reminded of Tantalus when we saw, looking back to the place where we crossed the river, that not half a mile further down a beautifully clear mountain stream joined the Sutlej. Everybody who has walked much, especially in dry climates, knows what it is to be thirsty; but I doubt if they appreciate the sufferings read of in descriptions of travels through the desert. At any rate, what I felt on the occasion I describe seemed to me to be related to an ordinary thirst very much as the agony of fever-heat is to the pleasant feeling of warmth on a sunny summer day. When, after two hours' ascent, we reached a pool of water, there was no time lost even in picking a little goblet out of one's pocket; we simply lay flat down, one beside the other, and without enquiring whether the water was good or bad, clean or dirty, drank long draughts.

It began to get dark, and we asked ourselves whether we should risk the ascent, as the path seemed good, or follow the cautious advice of Dr. Brandis and stay where we were. The fatiguing day we had had perhaps inclined us to the side of caution; at any rate, we remained on the spot. Nearly all the luggage had gone ahead, but the mule carrying the cooking utensils was following us and we soon made a large fire, which attracted

thousands of fireflies. There were no huts, but we got hold of one of the mules which carried two of our tent-posts and my bedstead and, by means of a rug, made a protection against the rain, which again began to threaten. It was not easy to find room for three inside this improvised shelter, but we finally arranged that the bedstead should be put up for me to lie upon, while one of my companions just found room by my side and the other under the bed. I think, on the whole, I came off worst, as every movement of the man underneath gave me the sensation of an earthquake.

Starting at a quarter past six next morning, we reached the top of the slope after an hour and a half's march. On the way we found out the wisdom of having camped out during the previous night, for although the path was good, there were many sharp turns, and even one of the surefooted mules had missed its footing in the dark, and was found dead next morning at the foot of a rock, fortunately without any damage to its load. Passing along the ridge for another mile or two, we reached the village of Dalash, with its bungalow. The lower portion of the village has its houses built very much in the style of the Swiss *châlet*. The houses higher up, no doubt owing to their greater exposure to weather, are built of stone. There is a temple with curious figures carved in stone on the outside; but it was raining hard and we had not much inclination to look round. The rest of the day was spent chiefly in sleeping; our dinner consisted of portions of a sheep which we bought alive for two and a half rupees. The view, as far as could be judged through the clouds, reached

back across the valley towards Kotgarh and the hills above Narkunda.

It rained heavily during the night and we could not make an early start, but as we had already lost one day we were anxious to get on, so that when, after breakfast, there was a little break, we determined to make a start. The mules we sent back, as we found it too much trouble to load them, and we had no difficulty in getting twenty-six coolies to carry our baggage. This may seem a large number for three travellers, but it should be remembered that we were prepared for a two months' trip, and that we had to carry tents not only for ourselves, but also for our three servants, besides a quantity of provisions in the form of tinned meats, chocolate, etc., as we expected to be ten days or more out of the reach of any human habitation, without the possibility of replenishing our supplies. The natives of the villages who act as coolies are not very strong or active. They only consented to carry a load because they were obliged by Government to do so.¹ The tariff varied from four to six annas a day according to the length of the march. I do not know by what method labour of this kind was enforced. I only know that coolies were always forthcoming when we wanted them, though often they were obviously unwilling. Nor was it of any use to offer them increased pay, at any rate in the higher and more desolate parts, as they could do very little with the money and did not appreciate its value.

The path leaving Dalash took us up a gentle slope

¹For many years the system of obligatory service has been given up in British India.

until after three-quarters of an hour we reached a ridge only a few hundred feet above the bungalow. Looking back we took leave of the arid Sutlej valley and descended into a pretty glen down to the village of Chawai, where we changed coolies. From Chawai to our next resting-place, Kot, we again ascended a steep slope, through fine forest scenery, which we should have enjoyed had it not been for the damp, close atmosphere, and the clouds which sometimes surrounded and sometimes wetted us with showers. We here became acquainted with one of the deceptions of Himalayan travelling. When you think you are close to the end of your journey you find that you have to cross a deep-cut valley which had escaped your notice, and which involves a steep and sharp descent followed by a tedious climb. Before reaching Kot, we not only had to cross one of these side valleys, but a rocky gorge, which, in the rain and with rapidly approaching darkness, was not free from danger. We might have avoided this gorge, but the coolies passing into it, no doubt because it was a short cut, I and one of my companions followed, thinking that we ought to be able to accomplish what a native carrying a long tent-pole and other loads can do in the way of climbing. It was quite as difficult a climb as many in Switzerland where ropes are used; but on this and other occasions I found the power of a native coolie, hampered by awkward tent-poles, to traverse a narrow hillside where there is hardly foothold, is almost miraculous. We reached Kot at 8 p.m. after an eighteen miles' tramp, but as usual found it took two hours till our dinner was cooked.

Next day, Sunday, was a day of rest; it rained all the morning, but we were able to take a stroll in the afternoon and made a vain attempt to inspect the inside arrangements of a water-mill, which we found locked. We noticed that the women wore large rings in their noses, and thick anklets. Although we saw Kot under very unfavourable circumstances, we could realize that it was a spot of great beauty. Rich pine-forests surround the village; we could look back towards Dalash and even see the hills of Narkunda and Kotgarh behind. Perhaps the rare glimpses of sunshine and the rapidly changing cloud-effects added to the charm, but all the same one felt that one would like to spend a few fine days in this spot.

There was a temporary clearance in the weather on Monday morning, the 26th July, and we succeeded in getting off at 7 o'clock; and a two hours' climb brought us to the so-called Jalori Pass, at a height of 10,500 feet. As we came out of the clouds after a short descent, the sky cleared and the sun came out and we were startled by a total change in the scenery. High mountain ranges covered with fir trees rose out of the rich meadows in the valleys. The aridness so characteristic of the Sutlej valley had entirely disappeared; and where a rocky precipice showed between the trees it was generally enlivened by a waterfall. The deep gorges which also cut into this valley rendered our walk a little fatiguing, but the fine weather and beautiful surroundings cheered us up and a short march of twelve miles brought us already at 3 o'clock in the afternoon to Jibi, our next station. It rained during the night, but fortunately cleared up in the morning.

Our road now took us through a shady wood a little above the River Ratti, a tributary of the Beas. Then, descending to the river, a distance of about five miles, we crossed it. The character of the country changed as we descended; and, as always in these valleys, the vegetation is rich and the scenery picturesque above a certain level, while below that level, probably owing to the action of floods, everything seems arid. It is needless to describe the details of our thirteen-mile walk to Larji, although there was a good deal of variety introduced by the uncertainty of the road, the path often having been completely swept away by landslips or buried under falling rocks. I remember one place especially, where the river passes through a gorge, leaving just room for the path by its side, but, the river being swollen, the path had disappeared, and there was only the water rushing along between perpendicular rocks. Up these rocks we had to find our way somehow, testing the foothold at each step before venturing to put our whole weight on it, for a slip would have been absolutely fatal. We should probably not have run the risk, and made a longer detour, had not the coolies shown us the way with such confidence in themselves that we should have felt like cowards if we had not followed. On the next day we followed the river a short distance, until it joined the Beas, the valley of which we now had to ascend.

A story of personal discomforts is of little interest to the general reader, but they nevertheless have a great effect on the traveller's impressions of the scenery. During the first few days of our tour on the descent from Dalash, I got my feet thoroughly

wet, and walking on in soaking boots and stockings produced several bad blisters, especially on my heels. These got gradually worse, until it was impossible for me to put a boot on my left foot at all. I tried all kinds of substitutes; slippers answered as long as they lasted, which on the rocky roads was only a few hours; and I also bought some native shoes made of grass, but these were only a very temporary protection. Sandals were as bad as boots, as the straps came right over the tender spots. I finally had to walk miles and miles in stockings only, and occasionally with bare feet. Two or three days' walk barefoot finally disposed of the blisters. I found on these occasions that grass, though very tempting, is much more uncomfortable to walk on than a stony road, as the grass blades are hard and very sharp and easily cut the skin.

We ascended the Beas valley, which at first was narrow, but soon widened out, and became more fertile. Passing across what was probably the bed of an ancient lake, we found our next resting-place, at Mangalor. The natives here, especially the women and children, struck us as a stronger and finer race than we had yet met. We were informed that the valley was much frequented by bears, who descend at night from the hills to refresh themselves on the fruit trees, mainly peaches. But neither here nor later did I see any wild animals.

A short journey next day took us to Sultanpur, the capital of Kulu. I tried to get a horse to ride, and succeeded in securing an animal. There was no saddle or bridle. I got along part of the way with a light rug thrown loosely over the back of my

horse and a piece of string drawn through his mouth, but ultimately found walking, though with sore feet, more comfortable. We determined to have a rest-day in Sultanpur, which we reached on the 30th July. A short time after our arrival there, we heard a big noise, due to the sweeping away of the bridge over which our subsequent road led. Fortunately another bridge not far off had withstood the force of the river. The town of Sultanpur contains a regular bazaar, much resembling other native bazaars, though perhaps a little dirtier than most. It is bounded on both sides by massive stone archways, one of which contains the post-office. There is a great contrast between buildings in the bazaar and the houses which stand along the right bank of the Beas and which look neat and clean. In the upper valley, which we now entered, the banks are overhung by fine trees, forming a picturesque contrast to the rocky walls of the mountains behind. These mountains, like those of the other valleys through which we passed, are cut into by deep gorges covered in their upper parts with dark forests.

We reached Katrain at 2 o'clock in the afternoon. The bungalow lies on a plateau about 50 feet above the river, which was still so rapid here that we could only bathe under difficulties. We noticed a further change in the appearance of the inhabitants. The men have a decidedly Jewish appearance; they also have long beards and tangled black hair, and are very dirty. The women in Kulu wear plaits of false hair.

For the next day, the 2nd August, we had planned a long march and tried a new arrangement to secure an early start. I had some difficulty in overcoming the

pretty obvious opposition of the servants and coolies to it. I got up at 5 o'clock to call them up and despatch some of them with our breakfast. Instructions were given to stop at the next bungalow, Manauli, and there to have a meal in readiness for our arrival. We ourselves had another short rest and finally started at half-past six.

We still had the full force of the rainy season to contend with. It generally rained all night, though latterly we had been lucky enough to have clear intervals during the day, and often even we had to walk in the full blaze of an afternoon sun. On this day, however, we were unfortunate and could not get further than Manauli, which we reached at 10.30 a.m. The road from Katrain leads through fine forests frequently intersected by brooks, which by their coolness and clearness indicated that we were approaching greater heights. The Beas remains a broad river until about two miles below Manauli, where it is joined by two considerable tributaries rushing down from the hillside; one of them plunges into the main stream in a fine waterfall which, though not of great height, is impressive by its width and the luxuriant vegetation along its sides. The rain came down in torrents all the afternoon, but towards the evening I managed to find my way to a bungalow inhabited by Mr. Duff, the forest officer in charge of this district, to whom I had a letter of introduction. I found him in the company of an English officer who had travelled much, and who gave me some useful information on our proposed journey through Lahoul and Ladakh.

Rain continued during the night without inter-

ruption, and just on the point of rising from our breakfast next morning, we were terrified by a noise like that of thunder, which seemed to come from the immediate neighbourhood of the bungalow. Rushing out, we found that a large rock had broken loose from the mountain and, sweeping past within a few yards of the hut, had dashed down into the valley below. It was followed by a waterfall bursting out from the gap left by the boulder, and we soon found that a broad stream of muddy water surrounded the bungalow, seeking an outlet to join the Beas.

A day's journey separated us from the first snowy range, and the mountains beyond were reported to lie outside the limits of the rainy season. Longing for dry weather and in spite of threatening clouds, we made up our minds to ascend to the last bungalow below the Rohtang Pass as soon as the rain permitted. We were fortunate in a temporary clearance and it was a day which, I am sure, is remembered by all of us. Walking upwards along the valley, we saw the river below still swelling and increasing in bulk, rushing along with a terrific noise caused by the rocks swept away and rolling along its bed. Here and there, beautiful little islands, richly covered, looked peacefully out of the torrent. Wherever we looked along the steep mountain sides, masses of water descended, sometimes as regular mountain torrents, more often simply springing out of an opening in the rocks, and falling in gigantic waterfalls down into the valley. Patches of deep red and yellow, due to the ferruginous soil left bare by landslips, added colour

on all sides. The trees, dark coloured pines, occasionally clustered together, or standing solitary and apparently unsupported except by the bare, almost vertical, rock out of which they sprang, added to the beauty of the scene. As the valley got narrower, and we ascended one of the rivulets which combine to form the Beas, the roar of falling water and rocks increased. Recently fallen stones covered our path, which in many places was completely swept away, and not infrequently we could see boulders bounding down the hillside a short distance away. One felt as if some unseen power was trying to prevent our reaching the snowy fields above, and hurling down its missiles to destroy or frighten the invaders.

We continued to ascend amid varied surroundings, sometimes climbing a steep slope, sometimes traversing a projecting ridge, or crossing numerous bridges, and reached Rahla about 3 o'clock in the afternoon, after a four hours' march. The bungalow is situated in a magnificent spot between the rushing stream and a forest growing on the mountain side; and waterfalls formed here also one of the most characteristic features of the scenery. Behind us we could see the green meadows reaching up a steep incline towards the Rohtang Pass. A little below the hut, the river forms a fall which may be compared to the Rhine fall at Schaffhausen in its width and moderate height. A few hours' walk next morning brought us to the summit of the pass, at a height of 13,000 feet. We had to cross a few snow-fields, and looked with curiosity towards the promised sunshine beyond.

Deep below us, and parallel to the ridge on which

we stood, flowed the Chandra. The side of the valley opposite is simply a wall of rock. The horizontal line low down, looking almost as if it had been drawn with a ruler, indicated the path we had to pursue the next day. Above the level at which we stood, we saw a picturesque amphitheatre of snowy peaks, surrounding a semicircular area covered with snow. We had now reached the end of the first portion of our journey, and after travelling 180 miles, were going to leave vegetation behind us and enter the wildness of the Upper Himalayas.

At the summit of the pass, I noticed curious heaps of stones, about two or three feet high generally, surmounted by a large vertical stone. I was afterwards informed that these heaps were formed by pious Hindus, each of whom, the first time he crosses the pass, adds one stone to the rest.

I had been much puzzled on several occasions during our journey by halos round the sun, such as I had observed for the first time near Singapore.¹ They were the ordinary halos formed by ice-crystals, but somehow or other I had never noticed them before, and the ordinary courses of physics did not then include meteorological phenomena, at any rate, beyond the rainbow. My diary is full of calculations made at various periods of the journey in vain endeavours to account for the colour effects by diffraction through spherical drops of water. I believe that these halos must have been much more vividly coloured than those seen in Europe. I also noticed the deep blue of the sky and the curious play of the

¹See also my "Scientific notes taken in the Himalayas" in *Nature* of 16th March 1876, vol. xiii, pp. 393-5.

clouds between the range of hills on which we stood and the one to the north of us. The wind was irregular, sometimes blowing in one direction and sometimes in another, and the clouds always dissolved above the narrow valley of the Chandra to form again on the colder hills of the opposite side.

We descended to Koksar on the banks of the Chandra and were now in Lahoul, a desert country where the few green spots, like small oases in the wilderness, are often separated by considerable distances. We had evidently come into a different climate; the cold wind sweeping down from the snow mountains entered the hut in which we had put up our beds. The region of the bungalows was left behind, but we were still following the regular route which many native traders take to cross the Himalayas into Yarkand and Central Asia. There were therefore definite camping-places even in the regions beyond human habitation. These spots are fixed by the necessity of obtaining water. It seemed strange to us that, after having to contend with the superabundant supply of the rainy season, we should now have to look forward to a time when every drop of water would be of value. But the rains followed us farther than we had expected, and we had not done with them yet.

On a few of the camping-grounds rough huts had been erected for shelter, and some of these so-called serais were also placed in exposed spots on some of the mountain passes. It was in one of these serais that we had taken up our quarters at Koksar. There is a striking difference between the appearance of the inhabitants of Lahoul and those of Kulu. Instead of

long beards, moustaches only are worn by the men, the eyes are narrow, and the appearance of the women reminds one of the Chinese type. The women are strong and good-looking while young. They do not wear rings through their noses or anklets or false hair. An ornament, apparently of silver, of the size of an English crown-piece is fixed to the hair, which is worn hanging down but held in by a curiously-shaped ornamented necklace. Another ornament generally binds the ends of the hair together. I tried to buy some of these ornaments, but did not succeed, in spite of offering a good deal more than their value could possibly be. Bargaining could, of course, only be carried on under difficulties; the Tibetan language spoken by the inhabitants was not understood by either ourselves or our servants, and thus even discussions about coolies and provisions had to be carried on by signs except when, as frequently happened, someone in the village could talk Hindustani.

This valley of the Chandra and that of the Bhaga which joins it are among the few spots on earth where polyandry is still practised. The brothers of one family join together in taking one wife, but sometimes, I am told, they add a second one who is also joint property. If one of the husbands desires a confidential chat with his wife, he leaves his boots outside her door, and that is a sign to the other husbands that their presence is not desired. A story is told of one husband who had the previously unheard-of ingenuity to buy an extra pair of boots, which he placed every night outside the wife's door. It took his brothers some time to find out the fraud.

I do not know whether it is because, or in spite, of polyandry that the women are a finer and stronger race than the men, who seem to take life easily. It is generally the women who act as coolies to carry the baggage. There is a characteristic difference in the way the two sexes get through their day's labour. The man, once he has his load given to him in the morning, sticks to it, and stolidly and silently carries it to the end of the journey, while the women keep up a constant chatter, and interchange their loads every half-hour, each of them thinking, no doubt, that the other has the lighter load to carry. Their beauty, where it exists, is spoilt by the layer of dirt which covers them; and as to their clothes, they hang on their bodies in such rags, that one feels absolutely certain that they could never be put on again if once they were taken off. I was told by the missionaries of Kyelang, of whom more anon, that a person's age is reckoned by the number of suits he is wearing. I forget whether it is five or seven years that a suit is supposed to last—that is to say, making the more charitable supposition, if a person is reported to be five suits old, his age is twenty-five. The suits are never taken off, and the new one is put on over the rags of the last.

Our first march in Lahoul brought us to Sisu, at a distance of eleven miles from Koksar. The road was uninteresting. We were walking along a path cut in a high wall of rock; opposite, on the other side of the narrow valley, was a similar wall, and at the bottom flowed the white Chandra, carrying its glacier water down towards the Chenab. The villages are built near the rare spots where a little rivulet irri-

gates the meadows, and where there is sufficient level ground to grow a few fields of grain. So precious is this irrigable land that the houses of the villagers have to be built amongst the rocks, where they are crowded together and look something like a fortification. Sometimes one common roof covers the whole village. Windows do not exist, and doors are avoided as much as possible. There is an opening in the flat roof through which the inhabitants descend by means of ladders, and these openings also serve for the smoke to pass out. When the village is built along a steep mountain side, the floor of one house is at the level of the roof of the one below, and to get to the topmost building you climb up by ladders from roof to roof. We met fine herds of sheep and beautiful long-haired cattle. It was a relief to be able to have a sheep killed to replace the eternal dry fowl of which our dinner had so far consisted.

At Sisu we had our only experience of active unpleasantness in the behaviour of the natives. We had just pitched our tents on a meadow, which we understood to be the regular camping-ground, when one of the servants called out to us, and we found a stream of water flooding the meadow and rapidly approaching our camp. We at once set the coolies to dig a little trench to divert the stream, and soon discovered that a sluice had been opened, no doubt with the intention of driving us away. This was the first night we spent in tents, and though it was cold, I enjoyed the feeling of fresh air, and ultimately got so accustomed to it that I remember the difficulty I felt later in getting to sleep within four walls.

A short march of eight miles next day brought us to Gandla. We were still passing along an almost level track down the Chandra, through the same rocky and stony country, but occasionally as we crossed a narrow gorge we could get a glimpse up towards the snow mountains. We met herds of goats coming down, each animal carrying a small load. I am not quite sure what this load consisted of, but both goats and sheep are used to carry burdens down from the hills and I understood that it was generally borax, which came from dried-up salt-lakes high up in the mountains. We had intended to get as far as Kyelang on that day, but on arriving at Gandla, were informed that the road was impassable, one of the bridges having been swept away. At Gandla there is a curious Lama monastery, which I sketched while the Websters went out shooting. One of them brought home a pigeon and the other an Indian grouse, a welcome addition to our supplies. The natives here seemed friendly, perhaps a little too much so, for in the morning when we had to carry on our ablutions in front of the tent, there was great excitement, and all the women formed a semicircle round us, taking the greatest interest in our proceedings, and especially in our articles of attire.

We had found out that we could avoid the broken-down bridge by taking an old and disused path. A little below Gandla, the Bhaga joins the Chandra; the proper route crosses the former stream by the bridge which had given way, so that we had to ascend the valley on the left side of the river, and crossed a number of deep gorges, each involving a steep descent

followed by an equal ascent. Finally we reached a spot opposite Kyelang, and were glad to find the bridge at this place still in good condition.

Amongst the oases of Lahoul, Kyelang is the largest and most fertile. It is the seat of a Moravian mission, and the grounds of the mission-house contain a rich orchard and vegetable garden. Corn and flax are also grown by the villagers. The two missionaries and their wives led a lonely life but seemed thoroughly content and happy. They gave me much interesting information about the inhabitants and the Lama religion which they follow. The Moravians had made no converts in Lahoul; but there was a small colony of Ladakhis who had adopted the Christian faith. It did not seem to me that these missionaries made any very great effort to promulgate their own doctrines; and they were probably right, because they had acquired a great influence for good in other ways, which it is very likely they would have lost if they had insisted on religious conversion. They were the doctors of the neighbourhood, and also acted as arbitrators in any quarrels. The natives apparently came to them voluntarily when any difficulties arose, and submitted their case, and the judgment of the Moravians was, I understood, always accepted as final. One of the missionaries seemed to have talent as a mechanic. He taught the natives to make all kinds of little appliances, and how to divert the little streams to irrigate their land.

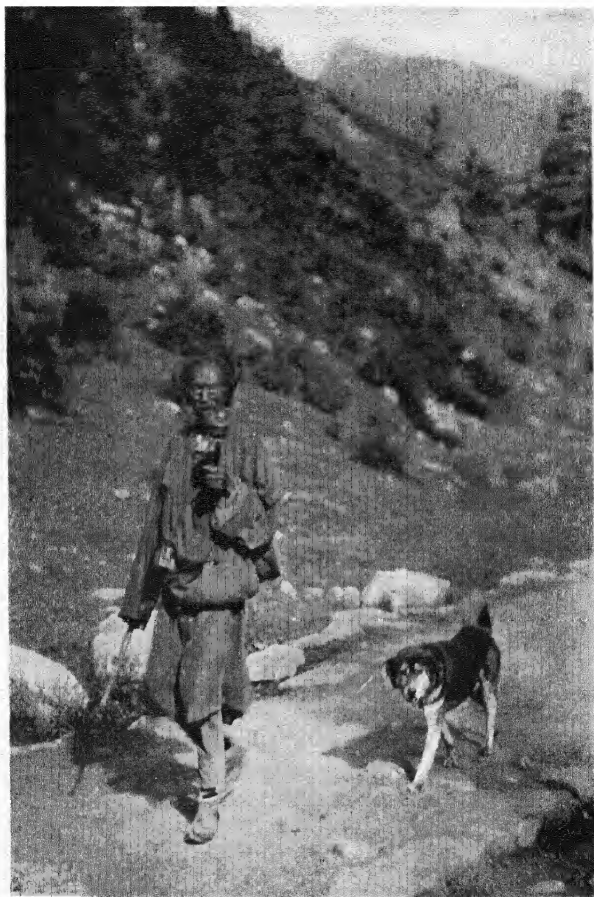
We found Mr. Bruce, a Government official, who, I believe, was in charge of the whole district, at Kyelang, occupying the whole of the regular camping-

ground, but the missionaries gave us permission to pitch our tent in their yard. During our walk, we had noticed some of the well-known heaps of stones found in countries which profess the Lama religion. Each stone has an inscription cut into it which always consists of the same four words, '*Om mani padme hum*' (Hail to the jewel in the lotus). It is sometimes said that travellers passing one of these sacred heaps cut an inscription into a stone which they add to the rest, but I was told by the missionaries that this is not the case. It is generally one man, who wishes to obtain merit for the expiation of a sin, who provides the whole heap.

There is a small Lama monastery about 2000 feet above Kyelang, to which I paid an interesting visit with one of the missionaries. It was an insignificant building, the passages and rooms often so low that one touched the ceiling with one's head. In front of the building was an open space on which the annual festivities and performances took place. The interior contained matters of interest, especially books that had been entirely made and printed by the native population and the priests. The paper is made from plants grown in the valley; the wooden blocks into which the lettering is cut are also home grown and made, and so is the printers' ink. In some of the books, the letters were painted in silver. The object, however, which interested me most was a picture painted by two of the natives of Lahoul, representing Buddha rising out of the lotus. The colouring was very gaudy, but all the same artistically distributed. Both drawing and colour contrasts showed considerable artistic feeling. It is needless to enter

into the complicated details of the origin and relationships of the Lama deities. I tried to fathom their genealogy with the help of learned books after my return, but the whole story is dull and uninteresting. There is only one particular god, whose image appeared in various forms in the monasteries, who seems to have any fun in him. He is the God of Evil Propensities, who does a good deal of damage unless he is properly propitiated. The inhabitants therefore bring him food, which, if he is well disposed, disappears during the night, nor will the priests offer any other explanation for its disappearance than that the god has eaten it. He is never happy unless he wears a cap made of golden thread, but sometimes he gets very angry and throws away his cap. In these circumstances a collection of money has to be made in the neighbourhood, and tranquillity is not restored until a new cap has been subscribed for.

Lamaism is a curious degeneration of Buddhism, mixed with a certain return to some of the ideas of Brahminism. In Buddhism a man's good actions almost automatically help him to improve his status in the next incarnation, while his sins pull him down. In Brahminism the most powerful of the gods are Vishnu and Siva, who, if appealed to by the inhabitants of the world, can force the other gods to grant their requests. Lamaism mixes these two ideas, and the prayer ranks equally with the good action in the Buddhist creed in making merit. It does not matter what the prayer is, nor whether there is any idea on the part of the individuals underlying it. A prayer therefore becomes simply one part of a piece



WANDERING LAMA TURNING A PRAYER-WHEEL

of automatic machinery; hence the origin of the prayer-wheel. There is only one prayer, or rather invocation, '*Om mani padme hum*', and this is written hundreds of times on a roll of paper. The paper is placed in a drum, and each time the drum revolves the prayer goes to heaven as many times as there are inscriptions on the roll. There are various devices for turning this wheel or drum. Sometimes the drums are fixed like a child's rattle on a short stick, and you see natives sitting on their doorsteps swinging one round, thus sending their prayers to heaven. Sometimes the rolls are fixed in larger drums, of which the axle fits into holes made in wooden supports fixed to the walls of the passages, especially in the monasteries. The passer-by will run his hand along them as he walks through the passage and give each drum a turn. It is wonderful how many prayers can be sent up in this way in a short time. From this it is only a small step to make the drums larger still, and to fix them to a wheel driven by water-power. The prayers then rise day and night and carry their record in favour of the man who has put up the wheel, or at any rate paid for it.

We made a halt of two days in this interesting spot, and the rains, which we had been led to believe never reached across the Rohtang Pass, once more threatened to cause us serious delay. On waking up on Monday, the 9th August, I found little pools of water in all the hollows formed by the blanket which covered me. The tents, though proof against occasional showers, did not resist the downpour which had lasted through the night. Captain Webster woke up with a bad attack of rheumatism, and native reports

came in during the day of the large amount of damage done higher up the valley by the rains. The mountain was tumbling down in one place, and many bridges had been swept away. The missionaries were very anxious about our safety and at first almost vetoed our going forward. The rainy season, no doubt, was not supposed to reach as far as this, but it was an exceptional season. (Has anybody ever travelled in a season that was not exceptional?) During the day, however, better news came in. The regular path on the right bank of the Chandra was not passable, but a way could be found on the other side and a bridge was still standing at Darcha to bring us back to the usual path.

As an example of the want of reliability of local historical traditions it may be noted that when the scene of the catastrophe which destroyed the road to Kashmir, as described above, was visited thirty years later, local authorities said that the event had happened two hundred years ago.

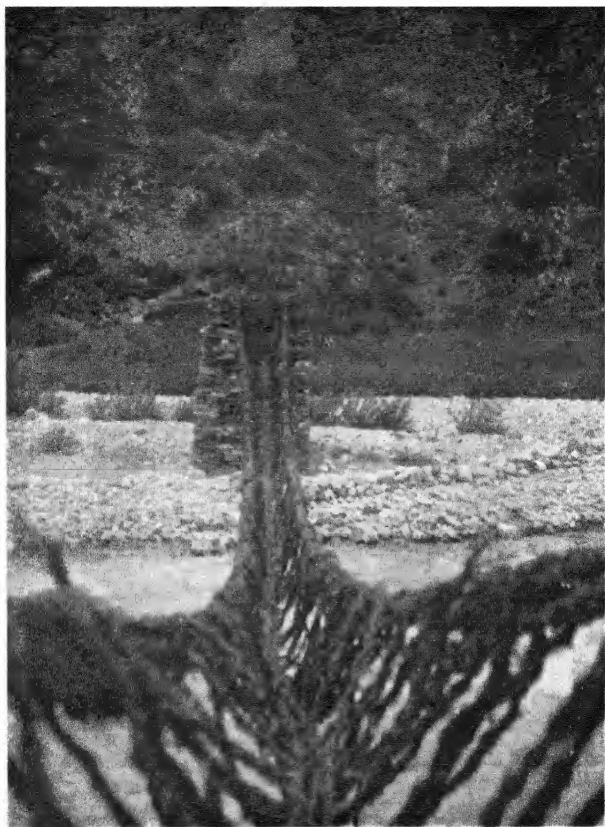
The weather having cleared, and my companion recovered, we decided to make a start on Tuesday morning, the 10th August. The missionaries gave us further useful information about our road and, what was equally welcome, a supply of bread and vegetables. Bruce was also very helpful, and, as we were soon to enter on a ten days' march in a country where neither food nor firewood were procurable, he sent a native messenger ahead of us to the Indus Valley, with instructions to send supplies to a pre-arranged spot on our road. Our first day's walk on the left bank of the Bhaga was along the hillside, a great part of which had been swept away by landslips, the

remaining portion being obviously on the point of sharing the same fate, but we reached our camping-ground at Timiun in safety. The description of the scenery which I entered in my diary is this: 'Rocks, rocks, a glacier stream, rocks and a small piece of green land on which Timiun is situated'. In the afternoon I was fortunate enough to be able to watch one of the natives weaving a piece of cloth on a primitive loom.

It rained again in the evening, but we were getting accustomed to camp life, and had our tea sitting down on the wet grass, disregarding the downpour. The road next day was over similar ground, with the addition of a hard and somewhat dangerous climb up a wall of rock. Everywhere we found signs of the destruction wrought by the heavy rains, rocks lying about which evidently had fallen down within the last few days, and even deep cracks in the mountain-sides. At ten o'clock in the morning, we found ourselves opposite Darcha, the last village we were to touch before crossing the high ranges lying before us. We were separated from it by the river, which was too deep and rapid to ford. The Bhaga here divides into two branches. Our only way of getting to Darcha was to follow up the eastern portion called the Milang, until we reached a bridge. Those who have not passed through a similar experience may find it difficult to realize what an obstruction a river can be. Here we were, within a hundred yards of the camping-ground, and only able to reach it after a long march up one bank of a river and down the other. The length of our march was increased even beyond our expectations by the fact that the

first bridge, which we reached after two hours' walk, was destroyed. We had to tramp another three miles, and by that time the coolies were tired out and grumbling and Captain Webster felt unwell. As his temperature was up to $103^{\circ}.2$ it became necessary to stop and camp out as well as we could. Next morning he felt better and we decided to undertake the three hours' tramp to Darcha.

We started the day by crossing the river, and got our first experience of a Jhula bridge. These bridges consist of three ropes stretched across the river, one intended for the feet, the two others, which are placed a little higher, being for the hands. The ropes are of plaited birch twigs and about the thickness of a man's arm. They swing about loosely, but are held together by strands of birch twigs. A structure of this kind is, naturally, not strong enough to stand tight stretching. It hangs down therefore in a curve which is more elegant to look at than pleasant to walk over. To get across the bridge you have to mount up a tower-like stone construction and, from the elevation thus reached, to descend to the middle of the bridge and reascend on the other side. After a little practice, there is really no difficulty about crossing a bridge of this kind. The birch rope gives a firm hold to the feet, and the guiding ropes give you a good feeling of security. All you have to guard against is starting the bridge swinging, the three ropes being of course capable of being set in motion in different directions. The natives, however, never like these bridges. This is perhaps due to the fact that they cannot be kept in good repair and the twigs gradually rot. Then an accident hap-



A JHULA BRIDGE IN FAHOUL

pens, and someone is drowned, after which a new bridge is stretched across.

I had been warned by the missionaries to avoid looking down into the stream. Not being inclined to giddiness, I could not, however, be expected to lose an opportunity of a new sensation. I got with comfort, though with a certain amount of diffidence, to the lowest point of the bridge, and then turned my eyes down towards the stream which was rushing past me a few inches below the level of my feet. I do not know whether any psychologist has ever investigated the illusions of the sensation of motion, which either make you believe that the surrounding objects are moving past you when it is really you who are moving, or, on the other hand, deceive you into the belief that you yourself are moving, when you are really stationary. Everybody has experienced the sensation of thinking that the train he is in is moving out of a railway station, when it is really the train on the next set of lines that is in motion; similarly, the country in the immediate neighbourhood of an express train appears to a passenger to be in motion. Most of us are accustomed to stand on the banks of a rapidly flowing stream, but I do not know that anyone has on these occasions had the sensation that it was he who was moving, and not the stream. Placed on this Jhula bridge and looking down into the torrent, the impression to me was quite irresistible that it was I who was moving, and I can still visualize the apparent rush with which I was carried from left to right together with the bridge, and the mountain-side in front of me. I do not know how long this

sensation lasted, but I can well understand anyone losing his presence of mind, and falling into the torrent. By an effort I lifted up my eyes, when everything at once fell back into its normal state of rest, and I could proceed with the ascent of the rope, and so reach the right bank of the river in safety.

We arrived at Darcha towards the middle of the day on Thursday, the 12th August, having thus taken 26 hours to get across the river. It was now necessary to provide for the ten days' march beyond the reach of human habitation. We had hoped to be able to procure some yak, the Himalayan wild oxen, which are easily trained for carrying baggage. Not being able to obtain any, we had to fall back on engaging twenty-five coolies for our journey. They were not very willing to come, and naturally so, as it involved an absence from their homes of more than a fortnight. Our food henceforward was to consist of tinned meat, rice, lentils, and chupatties, the native unleavened bread. There was hardly any space in Darcha fit for a camping-ground, and the place assigned to us was really the roof of a house.

As related above, the road from Kyelang to Darcha along the right bank of the river had been rendered impassable by the fact that one of the mountains was tumbling down. I wondered at the time what this meant, but during the evening and a sleepless night spent at Darcha I had ample opportunity of finding out. If you have seen an avalanche coming down a snow-slope in Switzerland, you can imagine the effect of four or five avalanches rushing simultaneously, and almost continuously, down a hill-side, each of them raking up a cloud of dust re-

sembling the cloud of snow which follows the Swiss avalanche. During the night the noise was intense and uninterrupted. Probably the amount of soil and rock carried down by each fall was comparatively small, but the total amount of disintegration must have been very large. The lower portion of the hillside was covered with the *débris*, and there was some danger of the river getting blocked.

The first part of our march on the Friday brought us to Patsis, a distance of eleven miles, where, we had been informed by the villagers, we should be able to provide ourselves with firewood for the following week. However, when we reached the place nothing in the shape of a tree was to be seen. I believe the coolies really had given us this wrong information in the hope of making us turn back altogether. When they saw we were determined not to give in, and if necessary to send them back to fetch wood, they gave us to understand that if we rested for a day they could get some shrubs from the hill-sides to serve our purpose. We asked them to set to work at once about this, and we ourselves went with them to superintend. There were, as a matter of fact, some low-growing shrubs, the roots and branches of which were sufficiently thick for fuel. A few hours' work collected a sufficient amount to get us over the next day or two, and though the coolies insisted that we should find nothing beyond, all their information was so obviously intended to keep us back, that we decided to push on as quickly as we could, but to collect as much fuel as possible as we went along. Owing to the delay which this had caused, it was night before we reached Zingzing-

bar. We had not, on that day, sat down to a meal from 8 a.m. to 10 p.m. We found no suitable camping-ground and passed the night in a stone hut, which evidently had recently been used to shelter sheep. The hut was not watertight and, as it kept on raining, we were most uncomfortable.

Next morning we had difficulty in getting our coolies to make a start. They were still unpleasant about the whole journey, and had had a long march of twenty-two miles on the previous day. At half-past ten we finally got off to ascend the Bara Lacha Pass. We saw little of the scenery—it was raining at first, and then came snow and mist. I had walked on ahead and, in spite of the bad weather, had some feeling of elation at walking above the height of Mont Blanc. There was a long, almost level, stretch at the top of the pass, and the large boulders lying about took all kinds of grotesque shapes, as they first came into view through the fog. As far as one could judge of the pass itself, it resembled one of the bleak passes of Switzerland, such as the Grimsel or Gemmi. We reached the serai of Kenlung after a march of twelve miles. Snow and hail were driving against the hut, and we were unable to get warm as our wood had to be saved for the more necessary cooking purposes. Next day was Sunday, but we had no time to rest, wishing to push through this desolate region as quickly as possible. We were happy to see blue sky at last, and, as it turned out, from this point onward, we had left the clouds behind. The coolies were again troublesome. We had to cross the river, and the path seemed to lead to a good road just below the serai.

They pretended we should find a bridge or better crossing place lower down. Whether they themselves did not know any better, or whether they were still in the hopes of making us give up our journey, I do not know, but they led us to a place which certainly looked rather forbidding. The water was icy cold, and in places so deep that it reached to the waist. Fortunately the river was not sufficiently rapid to carry us off our feet, though we had to walk with the greatest care. We met two travellers who had gone out to shoot in the hills, but were driven back by the bad weather; they told us that they had had a fortnight of constant snow and rain. However, we were enjoying the sunshine, and its welcome warmth, together with the invigorating and exhilarating effect of an altitude of 14,000 feet, soon brought back the enjoyment of the moment, without thought of the possibilities of the future.

The surrounding country in itself showed no evidence of its great height. We were in a flat valley, half a mile wide, through which the river had cut a deep bed. The mountains on either side did not rise much above the valley; their tops were rounded and monotonous and they completely hid the snowy ranges. We reached the camping-ground of Lingto after a march of seventeen miles. There were remnants of a bridge near Lingto which allowed us to replenish our vanishing stock of fuel. Our afternoon was rather spoilt by the absence of a coolie who had been carrying one of the tents. This caused us a serious delay next day, for, as he had not turned up, we were afraid he might have come to grief in crossing the river, and we sent back two coolies to look for

him. It was one o'clock in the afternoon of the 16th when these two men returned with the missing tent, which they had found soaked with water by the side of the river. There was no doubt that the porter had got his load wet in crossing, and, finding the wet tent too heavy to carry, had deposited his load and returned home. We were afraid of further desertions, for though all pay was deferred until we could dismiss the coolies, money is of so little value to them that they might readily have given up what we owed them for the sake of saving a few days' walk. We impressed the others with the fact that we meant to persist in our journey, and that, if any of them chose to run back, his load would have to be carried by the remainder without extra pay. We had no further trouble after this. We had only time to do a short march during that afternoon, and camped at a place which the natives called Kiom.

Next day we started for the ascent of the Lachalung Pass, which is still higher than the Bara Lacha. There are two ways up. The coolies told us they would go by the old road as they preferred it. We had lost our faith in their judgment, nor did we see what could have been the object of making a new path if it was not intended to be used in preference to the old one. We therefore left them to their own devices, in charge of our servants, and we ourselves struck out along the new path, which led in long steep zigzags up the mountain. We were surprised and pleased to find at the top of this incline a European camp belonging to Mr. Morris, an engineer who was superintending the cutting of a new road. He asked us to lunch. Chickens had now become a

novelty, and a glass of beer a great luxury. It was a further stiff and tedious climb which brought us to the camping-ground just below the top of the Lachalung. On Wednesday we crossed the pass, and descended a rocky hill-side to Sumkhel. The weather was fine now, the sun warm, but there was an icy wind sweeping down from the mountains. I put down in my note-book a recipe for making a country like the one we were in at that time:

‘Take a rock and magnify it a hundred times—this makes one of the mountains. Put five of these rocks together and pour thirty drops of water over them to form the rivers. With a big pair of bellows blow some air cooled in ice in strong blasts down the hills’.

On the morning of the 19th we woke up to find our wash-basins covered with ice. We made an early start to get warm, and a climb of a mile and a half up what looked like a sandhill brought us to the celebrated Kiangchu Plain, a high plateau about thirty miles long, which consists of a sandy desert bounded by sandy hills, partially covered with snow. It was supposed to be inhabited by blue hares and zebras or ‘kiang’, which give their name to the plain. However, we saw no sign of animal life except a few marmots. Three miles’ walk brought us to a little pool of stagnant water formed by melting ice, which still partly covered it, and we sat down to have our breakfast.

One of my companions, who had stayed a little behind, grumbled on his arrival that we had sat down at such an uninviting place, when, as he said, the most beautiful blue lake could be seen not a mile

away. The lake is indeed marked in some of maps, but the missionaries had warned me that it was all dried up, and had also told me to look for mirage effects, which are frequently seen on Kiangchu Plain. It was, indeed, a most perfect deception. We were approaching a knee-bend of plain and, in front of the hill at the end, there seemed indeed, to be a clear blue lake which showed a perfect reflexion of the mountains. Presently we saw two shepherds leading a flock of sheep, apparently wading through this lake, the men being seemingly immersed knee-deep in the water, while the sheep looked odd, their backs and heads only showing above the water. I measured the temperature of the air at different heights above the surface of ground because the bending of the rays of light which cause the mirage can only take place where there is a rapid diminution of temperature from ground upwards. I found that at an inch from ground the temperature was 56° F.; at 4 inches, 55° and at 5 feet, 49° F. The temperature of the lake could not be satisfactorily measured at the same spot because the ground was too hard; but when we reached the sand over which the mirage was formed which was four miles off, I found that the ground temperature was 90° F., thus showing an enormous difference from the temperature above, which was kept low by the wind coming down from the mountain.

We hurried on, partly because Ruckchin, our camping-ground, the first place at which water could be obtained, was still far away, and partly because we were running short of provisions, and Ruckchin was the place at which Mr. Bruce had given instru-

tions that we should be met by yak and provisions. We began to be a little anxious, as we should have been in an awkward position without fresh supplies. Shortly after noting down the mirage effects, we met two English officers, who gave us the most glowing accounts of the good-nature of the shepherd they had found at Ruckchin. 'It is a fine place', they said, 'and you can buy everything you want'. We were pleased at the time, but it struck us after they had passed that they had probably carried off the provisions that were intended for us. That indeed we found to be the case, when, after a long march, we arrived at the little side-valley of Ruckchin, and toiled up the hill until we could find a spot where the snow was melting so that we might obtain a supply of water. We found the little serai, near which we pitched our tents. A man appeared, but his hands were empty. There was nothing to eat, no yak. He did not quite know where they had gone to, and he professed himself to be very sorry to have given away all supplies to two gentlemen who had spent the previous night at the place. We were naturally angry, and threatened him with all kinds of punishment which he would receive for disregarding the orders of Bruce Sahib. He was very penitent, and promised to do what he could. Somehow or other, after some delay, a live sheep was produced. It was probably his own property, and had been left behind from the flock we had seen in the morning. Next day the yak also appeared, so that, much to their joy, we could dismiss our coolies. Four yak were sufficient to carry all our baggage. The night was again intensely cold; a glass of water standing in the tent

was frozen solid in the morning. Riding ponies were also forthcoming in a mysterious fashion, and we accomplished on them the fifteen miles which brought us to the end of the Kiangchu Plain.

We camped out at a height that cannot have been much below 17,000 feet. The average height of the barometer at that level is 15 inches, so that we had only half the normal atmosphere above us. I had felt no inconvenience from the rarefied atmosphere and was in excellent health, but my companions suffered a good deal from headache. I had, however, a good deal of difficulty in going to sleep that night, owing to shortness of breath. It was amusing to watch the feeble attempts of the candles to burn, and the light they gave was very poor. The extreme transparency of the atmosphere, which travellers in Switzerland are acquainted with, is observed in an exaggerated form all over the Kiangchu Plain. It was that partly which made the travelling there so tedious. You saw the end of your march ten miles ahead of you, and it seemed close by, yet never seemed to get nearer as you tramped along. By comparing however the clearness of the atmosphere at different points of the same level in the Himalayas, I was struck by the fact that altitude alone was not the only or even the principal factor. It was rather the absence of vegetation which always accompanied exceptionally clear air. Where there was vegetation, and especially cultivation, it was frequently hazy, and the hills in the distance acquired the richer colouring with which we in this country are familiar.

In the appearance of the sky at night I was chiefly struck by the whiteness of the planet Mars, which

looks red at the sea-level, while, on the other hand, the planets which are usually white looked bluish. This is, I think, interesting, chiefly from a physiological point of view. We are told that we have no innate idea of the sensation of white; that blue light forms our standard of white, and that therefore the stars which have the same colour as the sun are white stars, and that we judge all other colours by contrast with that standard. The researches, chiefly by Langley, which of course were not published at the time of this Himalayan trip, have since made us familiar with the large loss of blue rays owing to scattering which takes place in our atmosphere. It seems therefore quite natural that Mars, looked at from a height of 17,000 feet, should appear white as compared with Mars at the sea-level. But if the above idea as to the movable standard of white is correct, Mars should be red as compared with sunlight at all altitudes.

The feeling of solemnity which took possession of us during the stillness of the evening was increased when, suddenly, the narrow fringe of snowy peaks which we saw rising over the dark masses of hills in front shone out against the dark background of the sky, as if they were formed of bright silver thread. Gradually also the mountains in front were lit up by the moon, which soon burst out on the opposite side and illuminated the whole valley. We left the camp at the foot of the Toglung at eleven o'clock on Saturday morning and, after two hours' ascent, chiefly on foot, we reached the summit of the pass, at an altitude of 17,500 feet.

I suppose there are certain scenes in a man's life

which have been so deeply engraved in his memory that they involuntarily come back to him, sometimes in the middle of the night, sometimes sitting by the fireside, and even sometimes, suddenly, in the middle of his work. There are three mental pictures of this kind which I brought home from this Himalayan journey; the first is of our struggle up the inclines of the Rohtang Pass against the force of the water and the tumbling rocks; the second is of the view which opened out at the top of the Toglung Pass; and the third, of our entry into Kashmir, but the second is perhaps the most vivid of all.

We stood at a height above any ground in Europe. We had walked 400 miles across mountain ranges, getting higher and higher until we had spent the last nine days almost constantly at an altitude higher than any to be attained in Europe. Here we were, looking beyond the valley of the Indus, apparently at the foot only of the great mountains—one long range of snowy peaks in front of another higher one, and a higher one behind that, and so on until even the clear atmosphere could no longer transmit the rays of light, and sky and snow began to melt together into a transparent grey. We ourselves were below the line of eternal snow, which is here at a level of about 19,000 feet, though we traversed a few scattered patches near the top of the pass.

Our journey now led down hill. A zigzag path quickly brought us to a warmer climate, and we soon reached the fresh green of cultivated land. After a march of fourteen miles we reached Gya, a village with picturesque houses, the inhabitants of which seemed good-natured and intelligent. We passed a

number of *mani* heaps, and I found a stone sufficiently small to be brought away. I also noticed a number of *gompas* built into the rocks. Fifteen miles through a narrow valley between red rocks brought us to the village of Upshi.

It was a pleasure to see trees again and to be in a village which showed signs of civilization, the first we noticed being two millstones driven round by water-power, which the female inhabitants use to grind their corn. Bruce had told us that eggs and fowls could be obtained here, and we summoned the chief inhabitants of the village to conduct our negotiations. It was a matter of some difficulty owing to the language, there being only one man apparently who could understand a little Hindustani. After a lot of trouble, we ultimately succeeded in getting a few eggs, but the villagers were unanimous in swearing that there was not a fowl to be had. There was probably a little of the Buddhist feeling against killing a living creature in this reluctance to provide us with food. Everyone was most polite and pleasant; and ultimately they yielded to the logic of the situation—where there are eggs there must be hens. A deputation from the village brought us at last a haggard-looking little chicken; but three eggs, and such an unsatisfactory specimen seemed insufficient, and, in an access of sudden inspiration, I told my servant to try to convince them that the *three* eggs could not possibly have been laid by that one chicken. This was solemnly translated into Tibetan by the solitary Ladakhi scholar. They consulted together and saw the force of my contention, so that two more similar specimens were soon forthcoming.

A pleasant recollection associated with Upshi is that the water in the river was again sufficiently warm to bathe in. The river which we had followed during the last two days here joined the Indus, and we made a short march on the following day to Machalong. The Indus valley, being a little wider than those we had so far been accustomed to, allowed a distant view of the snow mountains beyond Leh.

A mile and a half from Machalong, and built into the rock, are what look like a series of forts, but are in reality an extensive monastery, the 'Hemis-Gompa'. With a free afternoon before me, I was seized with the desire to investigate its interior, and, accompanied by a native guide, rode up on a little pony to request admission. The Lama monks were evidently accustomed to receiving visitors, as they raised no objections, but first a ceremony of a not altogether pleasant character had to be gone through. I was placed in a chair in the centre of a small room and a number of monks stood round. They all looked inexpressibly dirty and most of them were marked by smallpox and other diseases. One of the worst of them took a number of dried apricots, and, opening his mouth, put the fruit half into it to sanctify it with his sacred breath. These apricots I was then supposed to eat so as to fit me for my visit to the holy buildings. My native companion, who came in with me and stood at the door, greedily got hold of a few apricots, and the pleasure with which he devoured them showed that he ascribed some magic spell to the monk's breath. I was overcome by such a loathing of the proceeding that it took me a few moments to appreciate the humour of the

situation. I then condescended, for the first and only time in my life, to a piece of successful jugglery, the apricots going up my sleeve instead of down my throat. I was very proud at the time of having deceived the monks, and it was not till after my return home that I found out that the Lama monks are systematically trained in sleight of hand and jugglery. It forms their great hold on the minds of the ignorant peasants, whom they annually impress by public magic performances at certain stated festivals. I am now quite convinced that they were fully aware of my clumsy trick. Whether they considered me as a worthy but ill-trained brother, or whether they only felt contempt for my ignorance, without further remark they took me round the building, which, however, contained nothing of interest. A few badly carved wooden idols with a plate of food in front of them, and a few badly painted pictures, were distributed through the various rooms. The passages were all lined with prayer-drums, and a few larger ones were to be seen in the yard.

On leaving the building, I was surprised to find one or two of the monks holding out their hands and saying, 'Baksheesh'. It is a word with which one does not always associate pleasant ideas. It pursues one all through the East and one finally gets impatient of the frequency with which it is dinned into one's ears in and out of season. But on this occasion a feeling of joy came over me that I was again in a region of civilization where money has its value, and I saw my opportunity. Going towards one of the walls, I found a small prayer-drum rather loosely fixed in its bearings. I pointed to it with one

hand, holding a rupee in the other. I was understood, but bargaining was out of the question. The language of signs was the only available one. There was a great consultation between the monks, and much shrugging of shoulders and shaking of heads, but I was quite comfortable where I stood, and smilingly kept my place. I must have remained there about five or ten minutes without trying to say a word, when they were evidently taken by a desire to get rid of me. They were good-natured mortals, forcible ejection did not seem to appeal to them, and, after all, a rupee was a rupee. Ultimately one of them came towards me, detached the prayer-wheel and handed it to me. I was a little amused when, after receiving the rupee, they once more uttered the magic word 'Baksheesh'. They evidently knew that the money they had received, being in payment for goods delivered, could not be called by that name. I was too pleased with my purchase not to be liberally inclined towards them.

I much value this prayer-wheel, and not less so the dried apricots which I had *not* eaten. This fruit forms a common food in this district, and is really very good when untainted by the flavour of a Lama monastery. I once took the prayer-wheel to pieces. The wooden drum is in several sections, bound together by strips of goat-skin. The parchment inside looks very old and crumbling to pieces, so the writing is illegible, but probably only consists of '*Om mani padme hum*'.

Beyond Machalong the valley becomes more fertile and the river flows through a rich green strip of land. The houses are sprinkled about, generally half-hidden in birch-copses, so that each of them looks in the



PRAYER-WHEEL WORKED BY STREAM, NEAR LEH

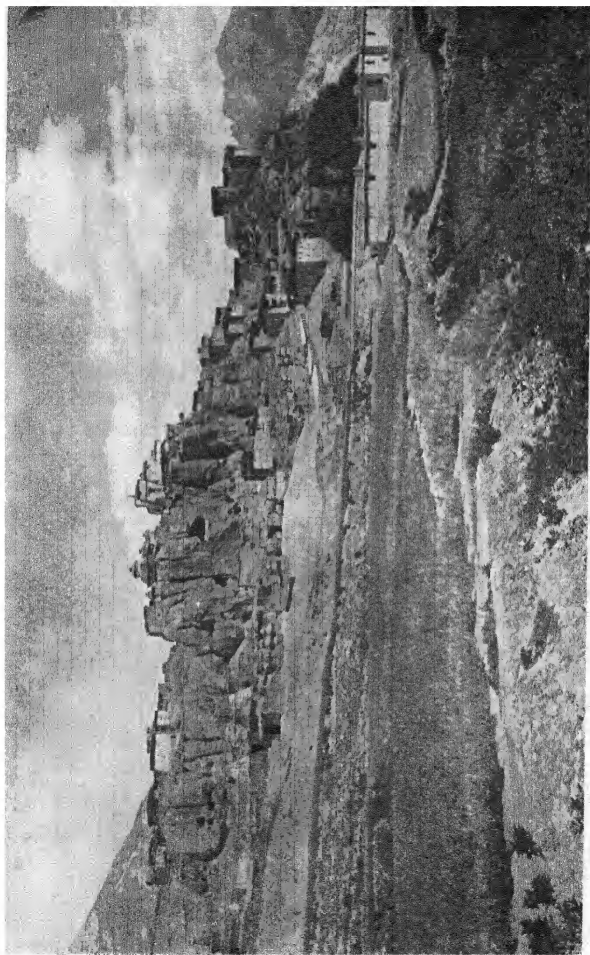
distance like a country house standing in its own park. In reality, they are only adobe huts. The corn was ripe and the inhabitants were busy cutting it. Caravans of Mahomedan traders with loaded mules were frequently seen camping out on the open spaces in gaudy tents. There was also a good sprinkling of half-naked children, who ran about the fields, often occupied in collecting the straying ponies and mules. In contrast with this lively scene were the barren rocks which bound the valley on either side, while beyond, the snow mountains stood out against the deep blue of the sky.

It is curious that though I felt perfectly happy while walking through the lonely regions, the more fertile and civilized valley of the Indus awakened recollections of home and brought back to me a sense of the distance which separated me from my family. I had then the first and only attack of homesickness I ever remember feeling. We intended staying a night at a place called Chushot, but I felt so unhappy at the idea of an inactive afternoon that I persuaded my companions to push on to Leh. Luckily, our baggage, now carried by yak and conducted by drivers mounted on ponies, soon arrived, so that after lunch, at which for the first time we enjoyed fresh milk, we completed our outward march and reached the furthest point of our journey, Leh.

Three miles from Leh, the Indus is crossed, and the road for a short distance leaves the river and passes through a rocky defile. We had to traverse the streets of Leh before coming to the bungalow. The streets were full of a noisy crowd of mixed races, Punjabis, Yarkandis, etc. Leh, a town of some

importance, is the capital of Ladakh, a province of Kashmir, and has a British resident. We took a three days' rest at Leh, and were well received by Captain Molloy, the resident, on whose table appeared the first game we had seen during our Himalayan trip. I inspected the meteorological observatory, and found in charge an intelligent native observer who seemed to take great interest in his work. The records showed enormous differences in the temperature between summer and winter. Thus one entry on the 20th January 1874, 10 a.m., gave $-14^{\circ}.8$ F. for the dry bulb and $-17^{\circ}.0$ F. for the wet bulb, while at 4 p.m. on the 24th August the dry bulb registered $75^{\circ}.8$ F., with the wet bulb at $55^{\circ}.0$ F. The barometer seemed to vary little above or below 19.6 inches. There is a palace with the Rajah's throne, which, however, is poor and insignificant. A large image of Buddha, housed in a separate building is, I believe, considered a great sight, and is an object of pilgrimage to the devout Lamaist; but after having seen the impressive images in Siamese caves I thought it really a most ludicrous object. You enter through a door into a room where you see nothing but the Buddha's feet, then you climb by a narrow staircase to the room above, where you may admire a further portion of the Buddha's legs, and so gradually stage by stage, climbing up the different stories of the building, you reach the head.

A curious little incident, which shows how far we had been away from civilization, may be mentioned. When I arrived in Leh, I was fully convinced it was Monday, the 23rd August. Next morning, calling



LAMAYURE MONASTERY

on Captain Molloy, I incidentally mentioned the date and day of the week. 'But you are wrong altogether', he said, 'yesterday was Tuesday, the 24th'—one day seemed to have completely disappeared, and it was some time before I found out where it got lost. For two or three days it had been so cold I had left my diary unwritten, and then, when filling it up, I forgot to enter a short day's march, with the result that for nine days we had been one day out.

The road from Leh to Kashmir, along which we were to proceed, continues for three days along the Indus valley; the first two camping-places are Saspul and Nurla, and the whole distance from Leh to the latter place is fifty-one miles. A short way beyond Nurla we crossed over to the southern bank of the river and soon began to ascend a narrow side-valley along a small dirty brook. A long march, which I estimated to be fully eighteen miles, although it had been described to me as only fourteen, brought us to the very curious-looking little town or monastery of Lamayuru. Large pillars of some conglomerate formation rise out of the valley and on these the town and monastery are built.

Our next stage was Kharbu, which we reached after crossing the Fotu Pass, 13,400 feet high. We had some amusement here and at other places owing to the fact that we were travelling along the same route as a caravan of Yarkandis. They were fine fellows and rode on mules, the like of which I have never seen before or since. They always seemed very anxious to get a little ahead of us so as to secure the best camping-grounds, but we soon discovered how to keep our own end up. They disliked intensely that

we should pitch our camp higher up the stream and so contaminate their water; and whenever we thought that they had taken an unfair advantage of us, in being first on the field, we settled down a few hundred yards above them. This always produced a great commotion, and sometimes they left us in possession. In spite of these little incidents, we got along very well together, and though conversation was impossible, there were many little signs of good feeling.

Our journey led us now through country which did not present any feature of interest, and which has left little impression on my mind. After crossing the Namika Pass, we entered the valley of the Wakha river and, having spent two nights at Kharbu and Shargol respectively, reached, at the end of the third day, the village of Kargil, which, to judge from its size and the nature of its buildings, seemed to be a place of importance. Two miles below Kargil, the Wakha joins the Suru, and shortly after the Suru is joined by the Dras. A two days' march up the latter river brought us to the village of Dras, which lies on a high grass-covered plateau. We there met an Englishman, Mr. Percy, who had been shooting in the neighbourhood, and, as he was returning to Kashmir, we joined forces. The next night brought us to Matayan, still on the same plateau, and here our English friend demonstrated to us the efficiency of a method of obtaining supplies which, though it proved successful, did not altogether appeal to our peaceful sentiments. We had been informed that milk could be obtained in a solitary hut situated near the camping-ground and, directly after our arrival, asked the native inhabitant of the hut for a small



ROUTE TRAVERSING GORGE BETWEEN LAMAYURU AND
THE INDUS VALLEY

supply of it. He utterly denied that any milk could be had within four or five miles. Soon afterwards Percy arrived and told us that on a previous occasion he had been supplied with milk there. The man was therefore summoned again, and after repeating his denials suddenly felt the impact of a strong fist on his face. Without saying a word, he turned round and fetched the milk. In the evening Percy told us that as no supplies of any kind could be had at the next camping-ground, we had better take some milk with us. The man was summoned again, but with much emphasis declared that we had taken every drop of milk he had. The method used in the afternoon however produced at once its effect, and the empty bottle which had been handed to him was speedily returned full. The man was, of course, well paid for the milk, but he presented a pitiful spectacle next morning with two black eyes. Percy was anxious that we should understand that he would not take similar proceedings with a Ladakhi, or a native of the Indian plains, but that he had noticed that the man was a Kashmiri, which meant that he was a liar and a coward, and that only personal violence would have any effect on him. How far this is a correct appreciation of the Kashmiri character I had no opportunity of judging.

From Matayan, the path leads up the Zoji La, the pass that was to bring us into Kashmir. There is a unique feature at the top of this pass. This is a waterfall so evenly balanced on the watershed that according to the direction of the wind, the water may either fall into the Dras, and

thence into the Indus, or fall into the Sind and join the Jhelum, which, of course, ultimately unites again with the Indus, but not until that river has made an enormous sweep round the Himalayan mountains.

The descent into the Vale of Kashmir is steep and accompanied by a rapid change in the vegetation, which, from the monotonous meadows of the Dras plateau turns first into birch-woods, then deodar forests and, lower down in the valley, plentiful fruit trees spread over cultivated fields. On us, who for more than a month had been travelling through country which, though it may be beautiful in places, mainly impresses one by its wildness and monotony, this sudden entry into the most beautiful valley, of probably the most beautiful country on earth, produced an unforgettable effect. It seemed like returning to one's friends after long banishment, or like waking up at home after a dream that had carried one into the Arctic regions. This sense of being home again was increased by the letters and newspapers which, for the first time since our departure from Simla, reached us on that day. Captain Molloy had been good enough to send a message to Srinagar asking the postal authorities to send a messenger with all our letters along the route by which we were going to travel, with instructions to look out for us. We ought to have met the messenger several days previously, if he had followed his instructions properly, but Captain Molloy had exactly foretold what was going to happen. 'The Kashmiri,' he said, 'will never leave his country if he can possibly help it. The man will no doubt quietly wait under a tree near the top of the pass until he sees you in the dis-

tance. He will then rush forward and try to pass you, panting for breath as if he had been running all the way from Srinagar.' I was on the look-out for him, and when, about 100 yards down the valley after traversing the pass, I found a native answering to this description, I stopped to ask him what he was carrying. He first produced two bottles of beer, and then a batch of letters and papers addressed to us. All these he made no difficulty about handing over, and reaching Baltal, at the bottom of the first steep incline, we spent a happy afternoon with our mail. In the evening, I went with Percy on an unsuccessful expedition to look for bears, which were supposed to be very plentiful there, and so tame that it is not considered sportsmanlike to shoot them.

If the upper valley of the Sind, near Baltal, had struck us as beautiful and rich, it was probably by contrast with the country we had passed through, and because our eyes had ceased to be accustomed to anything more interesting than a blade of grass or a thinly grown field of oats. To those coming from the Vale of Kashmir itself, these portions of the valley must appear poor and barren. At every step downwards from Baltal to our next station, Sonamarg, the scenery increased in beauty. The foliage of the trees was already tinted with autumn colours, and there was an endless variety of greens. I am unable to describe the grandeur and charm of the view from Sonamarg itself. At the time I was reminded of the finest examples of Swiss scenery: snow mountains, glaciers, corn-fields, and trees were all represented, but when during the following summer I travelled in Switzerland on purpose to be able to

compare my impressions I was struck by the want there of the rich vegetation which adds so much to the beauty of mountain scenery. If one imagines the flora of the lower parts of the Italian side of the Maloja Pass surrounding the rocks and ice of the Chamonix valley, one gets some idea of the character of the upper valleys of Kashmir.

There is no temptation to pass quickly through such country, and we took four days to cover the distance of forty-four miles from Sonamarg to Gandarbal. The valley, which was narrow in places, opens out below Gagangir and becomes richly filled with walnut and apple trees. Gandarbal lies on a lake in the wide plain, which is properly called the Vale of Kashmir. The journey from Gandarbal to Srinagar is accomplished in boats. We reached that town on Tuesday, the 14th September, and pitched our tents under the beautiful trees of the Chenar Bagh, the regular camping-ground being filled by the influx of visitors which takes place about that time of the year from the plains of India.

Srinagar is a large town built on the banks of the Jhelum, and among canals stretching out on both sides from the river. Seven bridges join the banks of the river and one chiefly struck me as resembling the Ponte Vecchio in Florence, though it is on a larger scale.

I believe this bridge with its houses, as well as a great part of the old town of Srinagar, was burnt down a few years after my visit. The lazy life I led during the days spent here was a pleasant rest after all the fatigues of a march across the mountains. There was no temptation to walk. The tent is

pitched close to one of the tributaries of the Jhelum, and after a swim in the river, you lie down in a boat and are rowed about to see the sights of the town. The boatman knows how to make you comfortable with cushions and pillows, and, lying on your back looking towards the blue sky, the feeling of oriental indolence comes over you. Fruit in quantity, amongst which delicious grapes remain especially in the memory, are brought to you, and you do not feel that anything in the way of sight-seeing is needed for complete happiness. But it is well worth while to make the effort to step out of the boat and spend half an hour in visiting the shawl merchants and in looking over the products of Kashmir industry. On entering the house of a merchant, you are conducted to a large and apparently empty room. Servants bring you a comfortable seat and a table spread with tea and fruit. Then Summad Shah, or whoever it may be on the day in question, comes to entertain you. A number of servants bring in the shawls which are hung three at a time on the wall opposite you. It was like looking at a picture gallery—in fact, more enjoyable than most galleries. The rich and fresh colouring was as yet unadulterated with aniline dyes, and the oriental designs still had their character, though French buyers did their best to get them altered to their own tastes.

The merchant evidently himself enjoys looking at these beautiful things, and professes not to care at all whether you buy anything or not. He complained, however, that trade was bad, the Franco-German war having spoilt the Paris market, which up to then, had taken 90 per cent. of all the goods manufactured. I

believe the trade since that day has gone from bad to worse, and that now there are few of the genuine articles made.

There are, as is well known, three kinds of Kashmir shawls. The white woven shawl is made of down taken from under the long hair of a particular breed of goats, of which the Maharajah then reigning took extreme care. He would not allow any of them to be sent out of the country, and was reported to have refused enormous offers for the purchase of a few specimens. It is indeed very striking, when you travel through some of the outlying parts of the country where the goats are kept, to see how well they are looked after. Their fleeces are brilliantly white, and you never meet a flock without seeing at least one man engaged in combing out their long soft hair. The white shawls are noted for their extreme softness, and are so fine that they can be drawn through a wedding ring.

Of the other shawls some are woven with designs in colour and some are embroidered. The woven shawls are those which are the most highly valued. At the time of my visit, Rs. 1000 (worth then about £100) was quite an ordinary price. It was cheap considering the length of time they took to make. Some are reported to be the work of a lifetime. I was fortunate enough to be able to see one of the most noted weavers at work. I found him standing with a boy at either side of him. Each of them had a large number of small spools of brilliantly coloured woollen thread, which was to form the woof of the shawl. The man in the centre recited, in a kind of sing-song voice, words the meaning of which I could

not of course understand, but which conveyed to the boys exactly what they were to do. I have heard it said that the whole pattern is expressed in the form of a song which the worker learns by heart, but my impression at the time was rather that the man simply named the particular shade of colour to be passed through a certain number of threads of the warp. It is easy to understand what a long process the completion of a shawl must be when you watch them taking up not more than three or even fewer threads of the warp at once, and then changing the colour of the woof again. Strict watch was kept over all capable weavers, so that they should not leave the country; and though Kashmir shawls were supposed to be made by Kashmiri workmen in several places in India, they could only be made there by workmen who were discharged or were inferior, or probably not Kashmiris at all. It is not necessary to say much about the third class of shawls referred to, which are embroidered in silk, although they are also very characteristic and beautiful. Table-covers of the same kind of work are also made. I was told at the time that the dyes were all imported from China, and came *via* Tibet.

Another industry of Kashmir is the inlaid and beaten gold and silver work. I went to see one of the men at work, but his work did not seem to me to be good of its kind, and looked as if it were manufactured in a slovenly fashion for the European market.

On arriving at Srinagar, it is usual to engage a boatman, who in addition to the small punt for the smaller excursions also possesses a kind of houseboat, which in the centre has a covered space suffi-

ciently large to put up a camp-bed. He and his family live in the stern of the boat. The boatman also acts as a guide, and has got his own notions of what you ought to see. Amongst other things, he considers it necessary for you to pay a visit directly after your arrival to the Maharajah's dancing-girls. These live in separate establishments, generally three or four together, and are very much looked up to by the population. I had occasion to watch one of them passing through a native village, and was very much struck by the looks of reverence and admiration with which the inhabitants, including the priests, greeted her. They are on the whole not a bad-looking set, and are well dressed in white garments. The women of Kashmir, generally, are celebrated for their beauty, and indeed, one often sees well-grown girls with good features working in the fields. You meet occasionally one of these in the country districts, where it would evidently be inconvenient for them to walk over the bad roads with their veils on, but, when they meet a man, proprieties must be attended to, even at the cost of drawing their scanty garments over their face, and thus exposing the lower part of their bodies.

The Maharajah's government at the time I am writing about was thoroughly bad and tyrannical. Europeans were only allowed into the country by special permission, which, however, was not difficult to obtain during the summer. In winter, no one was permitted to enter, the reason being that the Maharajah then collected his taxes, and did not wish anyone to see the methods he adopted to squeeze payment out of his subjects.

I may mention two characteristic incidents of my journey through the country. One evening some coolies came to us, begging us to employ them next day. Surprised at this unusual eagerness for work, we asked them the reason, and this was their tale. The Maharajah was entertaining some Indian Nawab, who required 200 coolies to carry his belongings. To get the 200 coolies together, men had to be summoned from the whole district; some of them told us they had had a three days' journey from their homes. They were then to do a day's carrying and to return home, and for all that they received no payment whatever, and only a handful of rice for food during the one day they were actually at work. They had come to us in the hope of being engaged, so as to secure at any rate their twopence regulation wage. The other incident took place nearer the plains, where the Jhelum forms the boundary between British India and Kashmir. On the bank in British India there were well-cultivated fields of rice, corn and cotton, while on the other the land was absolutely barren. One of the inhabitants was asked whether there was any special reason for this. 'What is the use,' he replied, 'of our cultivating our land and working? We should derive no benefit from it. Everything we grow or make would be taken away from us.'

I made one excursion lasting a few days up the river, passing through Islamabad. I visited the so-called Pleasure Gardens of Atchibal, which I did not think worth seeing, and inspected the ruins of Martund, which I thought interesting, though I regretted not understanding the long explanation of

the guide. Bawan, where the sacred fish are shown, is close to Martund. More interesting was the excursion through the Dhal Lake to the Shalimar Bagh gardens built on floating islands.

I finally left Srinagar on the 23rd September, and was fortunate, on the first day of the journey out, in meeting Colonel Gordon and Major Collett, who had been travelling together in Kashmir. My previous companions had left me, one of them already before reaching Leh, and the other during my stay at Srinagar. I was, therefore, very glad to have two charming and interesting travelling companions. Major Collett accompanied Lord Roberts as Quartermaster-General, in his celebrated march from Kabul to Kandahar. The distance from Baramulla to Murree is 129 miles, which we accomplished in seven days, occasionally with the help of a pony. The road follows the river pretty closely, and at that time was thoroughly bad and very fatiguing. Whenever a side-valley had to be crossed, which happened pretty frequently, it meant a steep descent followed by an equally sharp rise. I reached Murree on the 30th September, having been sixty-two days on the road, and having covered during that time over six hundred miles.

The rest of my diary is a blank, and is filled by feeble attempts at copybook writing, which really were the result of enforced practice with my left hand, the right being disabled. It happened in this way. From Murree I drove down to Rawal Pindi, and here I had my first accident. Jumping down from a rather high seat next the driver, I caught my thumb in between two projecting bars, and wrenched it

with such force that I had just time to walk into the postmaster's office before falling down in a faint. I am not given to losing consciousness in that way; in fact, I have only done so twice in my life, and this was the first occasion. The postmaster was very much alarmed, and thought I had sunstroke, and that I was very foolish to wish to proceed on my journey. Though my thumb was very painful, I knew it was only a bad sprain, which did not require any special care.

I spent the night in an uncomfortable *dak* bungalow, crossed the Indus at Attock, and reached Peshawar the following day. I had been asked by Major Collett to stay with him for a few days in that town and I was very keen to see the celebrated frontier station, and if possible even to make an excursion to the Khyber Pass, which, however, owing to the unsafe state of the country, was out of the question even if I had been well. No one at that time was allowed to leave the town at night, as only a short time before, raids had been made by the Afghans into English territory. I was a little alarmed when Major Collett showed me into his very spacious and comfortable guest-room and expressed the hope that I would be all right, though he had seen a cobra in the room not very long before. But even a cobra is harmless, unless you accidentally step on it, or it happens to have chosen your bed as a resting-place, and you unwittingly displace it when getting in. But neither on this nor on any other occasion have I come across a cobra.

The first evening I was asked to dine at the mess with Colonel Gordon. It was already dark when

Major Collett and I got into a trap. The horse, which during his master's absence in Kashmir had probably not been given any proper exercise, bolted from the doorstep. Major Collett was holding the reins but was soon pitched out as the horse made a sudden swerve. At the time I thought he had jumped out, and was contemplating the wisdom of doing the same, but decided to stay where I was. The horse was careering along at full speed, for what seemed to me to be a considerable time, but could only have been a few seconds, and I suddenly felt one side of the trap lifting up, and I remember distinctly the sensation of relief as the thought passed through my mind that now my fate one way or the other would be decided. I was pitched out and probably should not have been hurt at all if my right hand had not been partially disabled by the accident on the previous day. No doubt desiring to save that hand from being brought into violent contact with the ground, I held it out, and it was unfortunately caught between the trap and the ground, the whole weight of the trap coming on to it. It was, in spite of this, a lucky escape. Following the wheel-marks next day, we found that the trap was upset by coming into violent contact with a stone at the corner of a little bridge leading out of Major Collett's garden and, had the horse succeeded in clearing that corner, I should probably have been thrown out with much worse consequences against the wall of the bridge. My hand swelled up so much that the doctor, who proved to have been my travelling companion on the *Surat*, could not decide whether any bones were

broken, and I do not know to this day. My hand was disabled for fully two months, and I have always had the mark of the displaced bone, as well as a scar on my nose. Major Collett was not hurt at all. This accident naturally spoilt a good deal of the pleasure of the remainder of my stay in India, as the shaking of a *dak* was absolute pain; and on the railway journeys I depended on the kindness of strangers to cut up my food.

I went to see Delhi, Agra and Lucknow, but these places are all so well known that it is hardly necessary for me to enter into any descriptions, especially as I have not the help of a diary to refresh my memory. Only one thing I am bound to say, although I shall probably lower myself in the opinion of some art critics. I was decidedly disappointed with the Taj Mahal. It no doubt stands among beautiful surroundings, and the brilliant whiteness of the marble must please every eye, but its general outline did not give me the impression of grandeur. When one looks at a well-proportioned building and tries to estimate its height, I think one generally finds that one has exceeded the actual figure. I think it is the reverse in the case of the Taj, and it seems to me to look better in a small model than it does in reality. Be the reason what it may, its shape did not satisfy me. My impression was very different with Fatehpore Sikri. The beautiful mixture of red sandstone and white marble seemed to me peculiarly suitable to the style of its architecture, and altogether the buildings seemed more natural, more impressive, and grander than the Taj. The same buildings also contain some beautiful details, especially the screens

of perforated marble. Amongst the purely marble buildings, I was also much struck by the Pearl Mosque at Delhi.

I brought home a few mementos of Delhi and Agra. Everybody who has travelled in the East knows the necessity of striking a bargain when you want to make a purchase, and even nearer home that art is sometimes useful. I have always acted on a principle which I think has been fairly successful. When the dealer has named his price, I have fixed in my own mind the sum which the article in question seemed to me to be worth. I did not consider so much its intrinsic value, but simply what I cared to give in order to possess it, and whether that was only slightly less than the price asked, or only half or a quarter or even less, I named my sum and stuck to it. I had no regrets if I did not get the article, and I did not mind if when having got it, I found that I had paid too much. Of one particular bargain at Agra I always feel proud. There is a native manufactory of inlaid marble work which much resembles the Florentine *pietra dura*. In fact, I believe that Italian workmen came to Agra at the time the Taj was being built, and introduced this work. A native dealer called upon me at the hotel, and exhibited a number of plates, amongst which there was one, and only one, which appeared to me to be worth having. He asked Rs. 100 for it. I told him I would give Rs. 10, and he laughed at me and left. The second day in the morning he came again, and placed the plate in the centre, and grouped his other inferior wares round it. 'You can have that plate,' he said, 'for Rs. 100 and not a rupee less, but if the Sahib can only afford

to pay Rs. 10 I have several plates that will suit him.' I told him I wanted to have that one plate and no other, and that I was not going to give more than Rs. 10 for it. He expressed his scorn at such an offer and packed up. On the third morning we went through the same proceedings. I told him I was going to leave that afternoon, and that I wanted to pack up at once, and so it was his last chance of selling me the plate. In fact, to bring him to the point, I took out my watch and told him that if he had not accepted my offer of ten rupees within the next five minutes, I would only give him Rs. 8. His feelings were very much hurt, but, saying that he would not even let me have it for Rs. 99, he left me again. I began to think that Rs. 100 must be the proper price, when, in the afternoon as I was sitting in the carriage on the point of driving away, the man came again, bringing the selected plate, and then the well-known collapse took place. 'Give me 100 rupees.' 'No.' 'Well then, 50 rupees.' '25?' '20?' '10?' I told my driver to start, calling out to the man, 'You could have got ten this morning. It is only eight now.' He ran after the carriage, 'Well then, let it be eight.' He got that sum and no more, and I really think I got the plate cheap.

I dismissed my bearer at Agra. He had followed me all the way from Simla and on the whole I was satisfied with him. Not expecting much truth and honesty to begin with, I was amused at a discovery I made a few days before he left me. When I engaged him, he gave me to understand that he only knew his own language, and that is considered rather an advantage, as the native servants who can talk

English are generally those who lay themselves out to entrap the new arrivals whom they can cheat with impunity. My Hindustani, which was nil to begin with, gradually improved, but I never really could express myself properly in that language. I think it was between Rawal Pindi and Lahore (there was no railway then) that some native labourers helped to get the wheels of the *dak* out of the mud in which they had stuck. I was taking out my purse to give them a small remuneration, when my bearer addressed me in fluent English, being very anxious that I should not pay too much and, of course, not wishing the natives to understand what he was telling me. The wish to hide his knowledge of English no doubt arose from the inborn curiosity of all Orientals, for he knew that I should speak to my friends more freely in his presence if I felt safe that what I said was not understood.

Of Lucknow I remember very little besides swarms of mosquitoes. Only once, and that in the West Indies, have I seen them in greater quantities. Their bites do not affect me much and I occasionally tried experiments with them. Putting out my hand flat on the table at the hotel at Lucknow, I counted the number of bites I got on it in five minutes. It was twenty-three, giving an average of one in twelve seconds. In the West Indies I got as many as forty, but I believe that there the time of exposure was longer. The West Indian mosquito is also worse in so far that when your body is covered with bites he puts on a second layer.

From Lucknow I proceeded directly to Bombay and thence home.

EPISODES

I. FREAKS OF MEMORY

MEMORY is a fickle servant which sometimes leaps to our aid spontaneously but, when most needed, fails to respond to our urgent call. More puzzling even than the extreme alternatives of perfect recollection and complete oblivion is the curious experience of what I may term mnemonic distortion. I can give a striking example of such a twist of memory.

In my childhood I was occasionally taken out for a day's excursion along the banks of the Rhine above Coblenz—a district full of striking and characteristic scenery. I got to know this country fairly well; its picturesque villages and ruined castles are not easily forgotten. After an interval of perhaps thirty years, I had occasion to visit these favourite haunts again, when I was astounded to find that, while the relative position of the geographical features of the district had remained in my recollection with perfect accuracy, the right and left banks of the river were inverted. It was as if I were looking at the reflected image of the scene and not at the scene itself. I am informed that such interchange has been experienced by others.

My second example does not relate to position but to size, and might perhaps be more correctly named 'mnemonic exaggeration'. It is not an experience of

my own, but comes to me through a former professor of psychology at one of the American universities, no longer, I believe, among the living. He marked on a clean sheet of paper a few simple figures such as a square or circle and handed the drawings round a class of pupils in a school. On removing the drawings, he asked the scholars to reproduce the figures from memory, paying special attention to size, and they did this with a fair degree of accuracy. After a week's interval he visited the school again and requested the pupils once more to make a drawing of the figures from memory. This procedure was repeated several times, with the result that the size of the figures was found to have grown after each interval. Some travellers' and sportsmen's tales are perhaps affected by such unconscious expansion.

I understand that such distortions are common, but there is one reminiscence fixed in my mind which presents such exceptional features that I should like to see it either confirmed or disposed of as a mere illusion.

In the University Library of Cambridge, students possess the very valuable privilege of taking, without further permission, books from the shelves for purposes of consultation. I frequently made use of this privilege and seem to remember more especially one volume, which contained detailed articles on scientific subjects. In my mind it stands out as a kind of precursor to our present-day *Nature*. I recollect, amongst others, a passage in which sufferers from gout are recommended to drink a white wine, known as Hochheim, which looks like being the origin of the term hock, now generally applied to this beverage.

In the same volume my memory finds references to the controversy between Newton and Leibnitz, the latter recognizing the priority of Newton in the discovery of the differential calculus, but begging Newton to admit the independence of his own (Leibnitz's) work. To this Newton is reported to have replied that it is only the first discoverer who counts, and that hence the question of independence did not arise. It is almost incredible that such a correspondence should have taken place, or that the Cambridge Library should contain such a volume without its being generally known. Some may be disposed to look upon the whole reminiscence as a dream. I suggest, as a possible explanation, that the correspondence referred to was conducted, not by Leibnitz and Newton, but by two irresponsible adherents of the two mathematicians.

II. AN EXPRESS TRAIN WITHOUT A SINGLE PASSENGER

I USED to wonder whether an express train had ever run between two important stations such as London and Edinburgh without carrying a single passenger. I can now vouch for the actual occurrence of this event, the train being the Orient Express, on the line between Paris and Calais. But the train was not quite empty, for it carried my Gladstone bag; that and nothing else, apart from the attendant officials. It happened in this manner. I was on my way home from Munich, anxious to take the shortest route; but, disliking the accommodation in the sleeping cars

during the day, I engaged my berth only as far as Paris. Barring accidents, I reckoned that I should have time to drive across Paris and take the ordinary boat-train, which was timed to arrive in Calais a few minutes ahead of the Orient Express. My luggage was booked through to London, which saved delays on the way. All went well until, on crossing the French frontier, I had occasion to buy a newspaper, in which it was mentioned that the passenger traffic across the Channel was so heavy that all seats had to be booked a fortnight ahead. This was bad news, as I thought I might be left stranded in Paris. There was, however, no need to abandon hope of maintaining my original plan, for I still had the possibility of falling back on the Orient Express if there were no empty seat in the *Rapide*. As a traveller of experience I knew, moreover, that vacant seats are often to be had at the last moment.

The Orient Express was timed to arrive at the Gare de l'Est in the early morning, and, after a short stay, to proceed to the Gare du Nord. I explained my intentions to the conductor of the train and requested him to reserve provisionally a seat in the express, and to look out for me at the Gare du Nord, where I should finally let him know in which train I intended to complete the journey. I also entrusted him with my Gladstone bag, to save time at the Custom-House. We reached Paris in good time, and I drove, as I had intended, to the Gare du Nord, where I found a good corner-seat in the *Rapide*. Presently the Orient Express crawled slowly in, and drew up at the platform where I was waiting for the conductor, who came along smilingly; but the smile disappeared when I

told him I was going on in the other train. He insisted that I must travel by the express and explained that otherwise he would get into trouble, because he had informed the headquarters of the company at the Gare de l'Est that there was a passenger, whereupon the company had decided to send the train on as usual. When I objected that they would have to send on the carriages to Calais in any case, he replied that when there was no passenger they attached the carriages to a slow train, which reached Calais in time for the return journey. Anyhow, he had my Gladstone bag and would stick to it. This led to a compromise. It was agreed that the Gladstone bag would act as my representative; that is to say, I was to pay ten francs as a *supplément* for its journey to Calais, but could myself take whichever train I liked. I had just time to get into my seat in the *Rapide*, and reached Calais ten minutes before the Orient Express. On its arrival I verified that my bag had indeed been the only traveller in the train.

III. A WILY IMPOSTOR

ONE day about the year 1890, while residing in Manchester, I received the visit of a young man, who explained, as the reason for his call, that he wished to interest me in two chemical substances which, he alleged, had remarkable optical properties. His story was, that he had discovered these substances while working in the chemical laboratory of one of the German universities. Speaking in German, he showed considerable familiarity with the

names and even with the work of the professors whom he mentioned. After submitting him to a pretty severe cross-examination without detecting any ground for suspicion, I came to the conclusion that he had passed through a university training, though I doubted his German origin. According to his account, which I subsequently verified, a well-known and important firm of chemical manufacturers in London had bought from him the right to prepare and sell his wares, subject to his retaining the power of sale for the small quantities he still had in his possession. He was therefore visiting the British university towns, trying to dispose of his stock at reduced prices. He showed me some documents signed by well-known personages, testifying to the scientific value of his samples. These included one from Sir George Stokes, whose handwriting was unmistakable, and whose signature was certainly genuine.

I was interested at the time in what was then looked upon as an anomalous behaviour of the passage of light through certain substances, the red being more refrangible than the blue, and there was nothing improbable in the discovery of some substance which would show that feature in an exceptionally marked degree. But I gasped on being told that one of the preparations which were being offered to me contained the colouring principle of the wings of a beetle, and the other that of the body of a blue-bottle. My visitor could not fail to perceive my surprise and incredulity, but remained unperturbed. He asked for a glass of water, into which he sprinkled a pinch of his small crystals. The green

fluorescence of the resulting solution was unmistakable. 'Eosin,' I said with a smile; 'a well-known dye.' Even this did not move him. 'I knew you would say that,' he coolly retorted, 'and I am going to prove to you that you are wrong.' He lifted the tumbler containing the solution; 'I drink this to your very good health!' he exclaimed, and emptying the glass, added triumphantly: 'You know perfectly well that if this had been eosin, I should now lie dead at your feet'. I was vanquished, for I knew nothing about organic poisons. Though I was unconvinced, his self-assurance had its effect. I bought a small quantity of his stuff and showed him out of the room. To my demand for his address, he replied that he was going to leave for Ireland the same evening. Realizing that I had been swindled, I wrote to the London firm, and they replied by return of post that they were satisfied of the *bona fides* of the man, their laboratories having reported favourably on the value of the preparations submitted. A week later they withdrew this statement and asked for a description of the man in order to report the matter to the police; but it was too late.

IV. HOW TO CATCH LIONS WITH FLY-PAPERS, AND THIEVES WITH A BAROGRAPH

THERE is no rational connexion between the two operations referred to in the title. Their relationship rests on the apparent incongruity between the object aimed at and the means by which that object is attained.

To capture a lion as you would a fly seems to

be a 'traveller's tale'. Nevertheless, it was successfully achieved at Gwalior in this manner, as related to me by the secretary of the Maharajah, who had imported lions into his State for purposes of sport. Once established in the jungle near the capital, the animals multiplied rapidly until they became a danger to the peasantry, who naturally resented this addition to the surrounding fauna. To avoid trouble it was decided to capture the animals alive, if possible, and keep them in confinement. As a method of capture, someone suggested fly-papers—an original but not quite obvious implement for the purpose. The lions were known to assemble at night in spots where they could find water, and the papers were spread over these places, the sticky side upwards.

When drinking time arrived the lions stepped on the sticky surfaces, and trying to remove the unaccustomed impediments by lowering their heads, soon found their faces covered. The more they struggled the more helpless they became, so that when morning arrived, the blinded and weary animals were caught in nets and removed to a large walled enclosure near the Palace.

I can only give a very simple example of the barograph method of catching thieves, because it is the only one I have had an opportunity of putting into practice, but I believe that with suitable refinements it might be applied in more serious cases. The essential feature of a barograph is a revolving drum with a pen fixed to a lever in such a way that the pen can trace a line on a paper stretched round the surface of the drum. If this paper be suitably divided, and the pen

suddenly moved up or down, the time at which the movement happens can be read to within half an hour.

It was about the year 1892 that an assistant of mine complained of petty thefts. He was in the habit of leaving overnight small coins in the pocket of a coat which he used when working in the laboratory. No one had access to the rooms except the night-watchman and the charwoman. To identify the guilty person it was therefore only necessary to fix the time of the theft. Two wires were introduced into the pocket, which contained a silver coin, fixed in such a way that when the coin was withdrawn an electric circuit was broken. This circuit contained an electromagnet which acted on a small piece of iron fixed to the lever of the barograph. The connexion being made with the coin in circuit, the pen of the barograph traced a straight line on the paper round the drum. When the coin was withdrawn, the circuit was broken, and the electromagnet ceased to act, so that the pen jumped upwards. The time when this occurred could thus be ascertained. The method was successfully put into practice on two successive nights and fixed the guilt on the night-watchman.

With a little elaboration, this method could be modified so as to supply a picture of the thief in the act of committing the crime. It would only be necessary to arrange that the interruption of the electric current should set a flash-light in action, having at the same time a photographic camera properly focussed and directed. Perhaps some day valuables locked up in safes will be protected in this manner—their removal furnishing automatically a photograph of the culprit.

V. 'PETRIFIED FOAM'

IN the course of a number of journeys I have been strongly impressed by the sight of the Niagara Falls, and have never lost an opportunity of renewing that impression. On one such occasion I was greatly surprised by seeing little ornaments set with semi-transparent stones for sale. According to the salesman they were manufactured from petrified foam found under the large falls, which was, he added, the only product of Niagara. H.R.H. Princess Louise, whose husband was at that time Governor-General of Canada, had accepted a brooch made of this material, of which I was shown a replica.

Later in the day I called at a curiosity shop where I had on previous visits made numerous purchases, and with the proprietress of which I was on friendly terms. Seeing some of the 'petrified foam' ornaments in her shop, I mentioned to my friend that they were entirely new to me, and asked her to tell me in confidence what the material really was. She replied that of course it had nothing to do with foam nor, incidentally, with Niagara, but was imported from England, and was in fact fluorspar from the Blue John Mine at Castleton in Derbyshire.

VI. A MISSED OPPORTUNITY

I HAVE often regretted never having had the experience of passing a few days in prison. It would have added so much to one's experiences. The pity of it is that I once had the opportunity and missed it,

through what I now look upon as sheer cowardice. Though it was only a minor kind of prison, and the sentence was a confinement of not more than twenty-four hours, a little imagination might have yielded at any rate a taste of the real thing.

It happened in this way. At the time of which I am writing (1873), students at German universities, such as Heidelberg, were provided with a card carrying their names and addresses. If they infringed the regulations in any public place, the powers of the police were limited to demanding the student's card, which was then presented to a university official appointed for the purpose. He had certain powers of punishment, such as imposing fines or sentencing the culprit to imprisonment in the university prison, called the *Karzer*. The conditions of imprisonment were not very severe, meals being supplied from a neighbouring restaurant; and, if the sentence exceeded a few days, the student might even obtain permission to see his friends and attend lectures.

I had few acquaintances amongst my fellow-students, but one evening found myself one of a party of three in a box at the theatre. The leading spirit was a Pole, the son of a landed proprietor who was preparing for his future responsibilities by pretending to study law, being himself the most lawless person I ever came across. After his father's death, he got into trouble with the authorities for not allowing German flags to be hoisted on his estate. The third member of the party was a Spaniard, a great favourite at such social entertainments as the town could provide. Ultimately he also got into trouble and had to leave the university.

On entering our box at the theatre we found a lady in one of its front seats, but as there was plenty of room to accommodate her, we raised no objection. The play was rotten, the actors equally so, and we soon ceased to listen and began to converse with each other, a very improper proceeding I must admit. We conversed mostly in English and French because the Pole refused to talk German on principle! When the curtain fell at the end of the first act, the lady rose and with an angry gesture left the box. Presently she returned accompanied by a gentleman, who ordered us to leave our seats and find places elsewhere, because we were annoying his wife. It appeared that he was connected with the management of the theatre and therefore assumed the right to order us about. This was too much for the Pole. With his fists clenched ready for a fight, he jumped up, hurling insulting remarks at the couple, and in particular referring to the difference in age between the elderly husband and the aggrieved young wife. The police then came up and we all three had to deliver up our cards. In due course we were summoned to take our trial. The plaintiff, assisted by a witness whom we had not seen previously, declared that we had disturbed the audience by expressing dissatisfaction with the quality of the play and had loudly threatened to throw rotten eggs at the actors. The husband laid great stress on the fact that his wife understood French and English perfectly, and this evidently impressed the judge. We were condemned to pay fines amounting to a few shillings and to confinement in the *Karzer* for three days in the case of the Pole, while the Spaniard and I

were let off with twenty-four hours. It was here that my chance came, and I missed it; for owing to the date of my examination for the Ph.D. degree being very near, I was afraid that my examiners would get to hear of the incident. The offence would then have been entered on the certificate issued to me on leaving the university.

As we were informed that we could appeal against the sentence by submitting our case to the civil authorities, we all three of us did so. I took advice from a banker, whom I knew to be an influential person, and he promised to make enquiries. He was a magistrate and might possibly have had to act as our judge. A few days afterwards he sent for me and told me that he had settled everything and arranged to have my sentence reduced to a fine, though the Pole would have to go to prison for one day. I asked him how he had managed to secure this clemency. It was all quite simple, he replied: 'I told them you were drunk and not responsible for your actions, and they took that as a valid excuse'. In due course the university judge sent for us again and told us that he had reconsidered the case and reduced our sentence to a fine for the two minor culprits, whereupon the Pole burst into tears and mollified the heart of the judge; so none of us experienced the *Karzer*, and my certificate carried the testimony that 'nothing detrimental to his character has been reported'. Incidentally, the banker to whom we owed the reduction of our sentence was himself condemned a few years later to a long term of imprisonment for fraudulent practices.

VII. POTENTIAL MATTER

A HOLIDAY DREAM¹

WHEN the year's work is over and all sense of responsibility has left us, who has not occasionally set his fancy free to dream about the unknown, perhaps the unknowable? And what should more frequently cross our dreams than what is so persistently before us in our serious moments of consciousness—the universal law of gravitation. We can leave our spectroscopes and magnets at home, but we cannot fly from the mysterious force which causes the raindrops to fall from the clouds, and our children to tumble down the staircase. What is gravity? We teach our students to accept the fact and not to trouble about its cause—most excellent advice—but this is vacation time and we are not restricted to lecture-room science.

Le Sage's particles are not satisfactory; they are too materialistic for the holiday mind; but I have always been fascinated by a passage occurring somewhere in Maxwell's writings, where Lord Kelvin is quoted as having pointed out that two sources or two sinks of incompressible liquid will attract each other with the orthodox distance law.

Let us dream, then, of a world in which atoms are sources through which an invisible fluid is pouring into three-dimensioned space. What becomes of this fluid? Does it go on for ever increasing the volume of that all-pervading medium which already fills a vast, but not necessarily infinite, space? When

¹Reprinted from *Nature* of 18th August 1898, vol. lviii, p. 367.

we speak of the constancy of matter, we mean only the constancy of inertia, and how are we to prove that what we call matter is not an endless stream, constantly renewing itself and pushing forward the boundaries of our universe? The conception of atoms as sources of fluid does not, however, necessarily involve such a perpetual increase of substance, for an equal number of sinks may keep withdrawing the increment.

These sinks would form another set of atoms, possibly equal to our own in all respects but one; they would mutually gravitate towards each other, but be repelled from the matter which we deal with on this earth. If matter is essentially dynamical, and we imagine the motion within an atom to be reversed, the question arises whether the reversed motion is similar to the original one; in other words, whether the new atom so formed may by a change of position be brought into coincidence with the old one. And if this is not the case, we must ask ourselves whether the new atom will behave gravitationally like the old one. If atoms are sources of liquid there would be no reciprocity, and the sinks would form another and so far unrecognized world. But sources and sinks compel us to the supposition of a fourth dimension, which belongs to the domain of nightmares, not of dreams, and we try to shake ourselves free from the idea.

I, for one, cannot quite succeed in this effort, for something has been left behind, which is not easily got rid of, when once its symmetrical beauty is perceived. Surely something is wanting in our conception of the universe. We know positive and negative

electricity, north and south magnetism, and why not some extra-terrestrial matter related to terrestrial matter as the source is to the sink, gravitating towards its own kind, but driven away from the substances of which the solar system is composed? Worlds may have formed of this stuff, with elements and compounds possessing identical properties with our own, undistinguishable in fact from them until they are brought into each other's vicinity. If there is negative electricity, why not negative gold, as yellow and valuable as our own, with the same boiling point and identical spectral lines; different only in so far that if brought down to us it would rise up into space with an acceleration of 981. The fact that we are not acquainted with such matter does not prove its non-existence, for if it ever existed on our earth, it would long ago have been repelled by it and expelled from it. Some day we may detect a mutual repulsion between different star groups, and obtain a sound footing for what at present is only a random flight of the imagination.

Even now some might argue that we possess some substantial evidence of repulsive forces. In our glorification of the Newtonian system we are apt to overlook some obvious facts which the law of gravitation fails to explain. One of these is the rotational velocity of our solar and of many stellar systems, which cannot be self-generated. Unless we throw our laws of dynamics overboard, or imagine the rotation to have been impressed by creation, we must conclude that some outside body or system of bodies is endowed with an equal and opposite angular momentum. What has become of that out-

side body, and how could it have parted company with our solar system, if attractive forces only were acting? Another unexplained fact is found in the large velocities of some of the fixed stars, which, according to Prof. Newcomb's calculations, cannot be explained by gravitational attractions only.

The atom and the anti-atom may enter into chemical combination, because at small distances molecular forces would overpower gravitational repulsions. Large tracts of space might thus be filled, unknown to us, with a substance in which gravity is practically non-existent, until by some accidental cause, such as a meteorite flying through it, unstable equilibrium is established, the matter collecting on one side, the anti-matter on the other, until two worlds are formed separating from each other, never to unite again.

Matter and anti-matter may further coexist in bodies of small mass. Such compound mixtures, flying hither and thither through space, coming during their journey into the sphere of influence of our sun, would exhibit a curious phenomenon—the matter circulating in a comet's orbit, the anti-matter repelled and thrown back into space, forming an appendage which is always directed away from the sun. Has anyone yet given a satisfying explanation of comets' tails? Is the cause of coronal streamers known, and can anyone look at a picture of the great prominence of the 1885 eclipse, and still believe that gravitational attraction or electric repulsion is sufficient to account for its extravagant shape? But this is not a scientific discussion. I do not wish to argue in favour of the existence of anti-atoms, but

only to give my thoughts a free course in the contemplation of its possibilities.

What is inertia? When the atom and anti-atom unite, is it gravity only that is neutralized, or inertia also? May there not be, in fact, potential matter as well as potential energy? And, if that is the case, can we imagine a vast expanse, without motion or mass, filled with this primordial mixture, which we cannot call a substance because it possesses none of the attributes which characterise matter, ready to be called into life by the creative spark?

Was this the beginning of the world? Is our much-exalted axiom of the constancy of mass an illusion based on the limited experience of our immediate surroundings? Whether such thoughts are ridiculed as the inspirations of madness, or allowed to be serious possibilities of a future science, they add renewed interest to the careful examination of the incipient worlds which our telescopes have revealed to us. Astronomy, the oldest and yet most juvenile of sciences, may still have some surprises in store. May anti-matter be commended to its care! But I must stop—the holidays are nearing their end—the British Association is looming in the distance; we must return to sober science, and dreams must go to sleep till next year.

Do dreams ever come true?¹

¹In a further communication to *Nature* of 27th October 1898, vol. lviii, p. 618, the author drew attention to a paper by Prof. Karl Pearson, under the title of 'Ether Squirts', published in the *American Journal of Mathematics*, vol. xiii, p. 309 (1891), in which Prof. Pearson worked out mathematically the theory of matter considered as sources and sinks of fluid, and showed that this theory implies the existence of 'negative matter', which may exist outside the solar system.

He also referred to a short paper by A. Foepl, *Ueber eine mögliche*

VIII. HOW I TRIED TO PULL THE LEG OF THE BRITISH ASSOCIATION

ON THE PROBABLE UNITY OF CHEMICAL SUBSTANCES¹

THE theory of the probable unity of chemical substances has recently received attention and I trust that the following attempt will be found to bring the question one step nearer to its solution. The arguments which I venture to submit to the British Association are straightforward and simple, and are based on a method of inquiry which has hitherto escaped the notice of scientific men. An example will best show the nature of that method. I start from the well-known chemical formula:



and submit it to the following simple transformation

$$\text{HH} + \text{ClCl} - 2\text{HCl} = 0,$$

$$(\text{H} - \text{Cl})^2 = 0$$

$$\therefore \text{H} = \text{Cl}.$$

This shows that hydrogen is equal to chlorine, and no assumption is made beyond the very plausible

Erweiterung des Newton'schen Gravitations-Gesetz (Sitzungsberichte der mathematisch-physikalischen Classe der k. b. Akademie der Wissenschaften zu Munchen, vol. xxvii, p. 93 (February 1897), and pointed out that the theory of Foeppl, though it differs from that of Pearson, also implies the existence of negative matter.

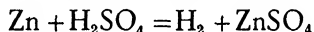
The letter concludes as follows: 'There are some points in my former communication to which previous writers have, however, not, as far as I know, drawn attention. Among them are the insufficiency of the ordinary hypothesis to account for the rotational momentum of our solar system which cannot be self-generated, the possibility of having evidence of anti-matter in comet tails and coronal streamers, and the idea of potential matter'.

¹This paper was presented to the British Association at Southport in 1903, but does not appear in the report of the meeting.

one that chemical formulae are subject to the laws of algebra.

I had obtained this result several years ago and privately submitted it to some members of the British Association at the Belfast meeting (in 1902), but I have hitherto refrained from publication, as the systematic application of the new method is not free from difficulties, some of which, at any rate, I desired to overcome before I ventured to challenge the criticisms of the scientific world.

I have recently found that my method really necessitates the introduction of a new idea which, when properly understood, will be found to shed a clear light on many hitherto obscure phenomena. I refer to the idea of the inverse of a chemical atom. I was first led to this idea by the following transformation. Starting from the formula by means of which chemists usually illustrate the evolution of hydrogen by the action of sulphuric acid on zinc,



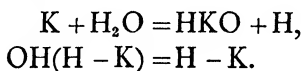
I obtain $(\text{Zn} - \text{H}_2) = \text{SO}_4(\text{Zn} - \text{H}_2),$

leading to $1 = \text{SO}_4 \text{ or } S = \frac{1}{\text{O}_4},$

which means that the sulphur atom is the inverse of the quadruple oxygen atom. This result, which seems startling at first, is amply confirmed by spectroscopic evidence. Thus, for instance, we find a line in the spectrum of oxygen at a wave-length 5190 and also two very strong oxygen lines at 4699 and 4415; multiplying these numbers by 4 and taking reciprocals, we find the first four figures of the numbers thus obtained to be 4817, 5320, 5663. Now it can

hardly be an accidental coincidence that, out of five sulphur lines which Hasselberg marks as especially strong, two should have wave-lengths of 4816 and 5319, being almost identical with the calculated values. Another line is also found at 5660.

The idea of the inverse of an atom requires some explanation. We might imagine that if we have formed a clear mental image of an atom we ought to have no difficulty in inverting that image. But a little reflexion will show that the idea of inversion necessitates the determination of some point to which the inversion relates. We are here brought face to face with a metaphysical difficulty which in some form or other meets us in every fundamental inquiry. I venture, however, as a mere hypothesis to suggest that the meaning of the formula really is that the sulphur atom and the quadruple oxygen atom are related to each other in the same way as object and image in a plane mirror. With K standing for potassium, we can connect hydrogen and oxygen in the following way:



The last equation is satisfied by $O = \frac{1}{H}$.

We have therefore found that

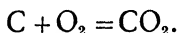
$$\begin{aligned} H &= Cl, \\ O &= \frac{1}{H} = \frac{1}{Cl}, \\ S &= \frac{1}{O_4} = H_4 = Cl_4. \end{aligned}$$

Summarising our results we have now shown that:

1. Chlorine is equal to hydrogen.
2. The oxygen atom is equal to the inverted hydrogen atom.
3. The sulphur atom is equal to 4 hydrogen atoms.

It is not my intention in this paper to enter into all the consequences of the new method, but only to show what it is capable of doing.

I conclude therefore with the application to the all-important detection of the absolute unit of chemical atomicity. When carbon burns, carbonic anhydride is formed, as shown by



Dividing both sides by the carbonic anhydride CO_2 we obtain

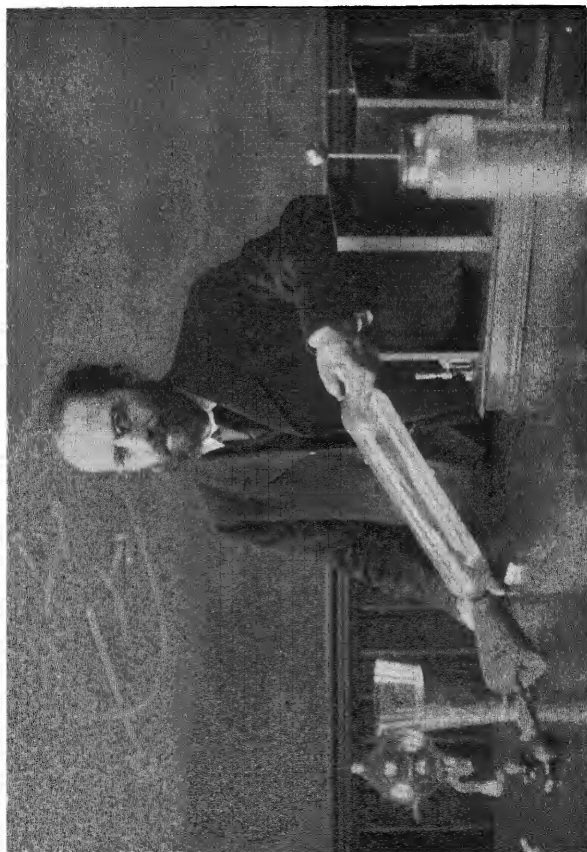
$$\frac{1}{\text{O}_2} + \frac{1}{\text{C}} = 1,$$

or, the absolute unit of chemical atomicity is the sum of the inverse carbon atom and the inverted double oxygen atom.

The equation teaches us, however, something more, and thereby confirms the meaning which I have attached to the inverse of an atom, for we see that the double oxygen atom and the carbon atom bear the same relation to each other as the conjugate foci in a spherical mirror, the principal focal length of which is unity.

I have carefully avoided in this short notice anything beyond a strict statement of facts and indisputable arguments. I have assumed that a strictly

scientific discussion will be more acceptable to the representatives of English Science at Southport, than daring speculations which, more brilliant but less illuminating, remind us of the flickering efforts of a panting and overworked dynamo.



THE AUTHOR LECTURING IN THE PHYSICAL LABORATORY OF OWENS COLLEGE, 1902

BIOGRAPHICAL BYWAYS

INTRODUCTION

THERE are things seldom referred to in obituary notices and sometimes omitted even in more ambitious biographies. They tell the tale of peculiarities or weaknesses which the writer fears may detract from the merits of the man he has set out to praise. The biographer believes, with some show of justice, that his main object is to give a record of work accomplished and not a psychological analysis of character. But eccentricities, or even decided failings, form part of a man's personality. The extent to which his teaching carries conviction and affects the scientific outlook of his time depends as much on his personal attributes as on the merits of his researches. We destroy the balance of a just valuation, if we ignore those shades of character or temperament which act as handicaps to the full fruition of his work.

It has been my good fortune to be acquainted personally with many of the men who laid the foundations of the science of the nineteenth century, and I have retained a vivid memory of such intercourse as I had with them. In writing down some of my recollections I have tried to outline personalities in a sympathetic spirit. If human frailties are sometimes exposed, I hope that the limits of allowable candour have never been transgressed, and that, apart from

the personal factor, the incidents related may be found to contain some substantial contributions to the history of science during the middle period of last century.

I. URBAIN JEAN JOSEPH LEVERRIER

(1811-1877)

I HAVE described in a previous chapter how I came to be put in charge of the eclipse expedition to Siam in 1875. Prior to this date I had never had any experience in mounting or dismounting astronomical instruments, and little in using them, and one of the appliances on which we depended—a large siderostat—was under construction and not expected to be ready before the eve of our departure. It was essential that I should get some knowledge of the instrument, and more especially of the process of silvering the mirror, which was to be a foot in diameter. A similar siderostat was in use at the Paris Observatory, where M. Adolphe Martin had found a simple and convenient method of silvering large surfaces of glass. I was therefore sent to Paris, with the consent of Leverrier, the famous director of the Observatory.

I first called on Cornu to ask advice on some optical questions that had arisen and, needless to say, I met with a most friendly reception both from him and other scientific men, notably Jamin. When Cornu heard that I was to call on Leverrier, he shook his head and said: 'Je ne sais pas si M. Leverrier est l'homme le plus détestable à Paris, mais je sais que

c'est l'homme le plus détesté.' This was not encouraging, and it was in fear and trembling that I entered the Observatory.

I was received by one of the assistant observers, C. Wolf, who remarked with a look full of sympathy: 'You will find M. Leverrier in a very bad temper; he has just returned from a funeral'. I was then barely twenty-three years old, and naturally looked upon Leverrier (who was sixty-four) as one of the formidable veterans of science. I was ushered into the 'Presence', received with a searching look and the abrupt question: 'Qui êtes-vous et que voulez-vous ici?' I mildly answered that I understood that Mr. Lockyer had written to explain the purpose of my visit. 'So he has,' said Leverrier, 'but I want to hear it from you.' After I had replied to the best of my ability, I was dismissed with the remark: 'I have already given instructions that every assistance should be given you'.

I spent an interesting and instructive week practising Martin's silvering process, which has the great advantage that the surface comes out polished, except for a thin veil which is easily removed without appreciable friction. When it was time to return home, I suggested to M. Wolf that it might be sufficient for me to write a letter of thanks to Leverrier without troubling him with a personal call. But Wolf would not hear of this, and I was shown again into the 'lion's den'. Leverrier was sitting at his desk and by his side stood a trembling young assistant to whom he continued to speak, taking no notice of me. I listened to a conversation of which I remember the main points without pretending to literal accuracy.

Leverrier. And so you tell me that after trying for a whole week you have not yet found the mistake in your calculations?

Assistant. No.

Leverrier. You have, of course, applied the correction for . . . (I did not catch the details).

Assistant. Yes.

Leverrier. Did you apply it with a plus or a minus sign?

Assistant. Plus.

Leverrier. It ought to be minus. That is your mistake. Go and correct your calculations.

After the assistant had left the room, Leverrier chuckled. 'I knew all along', he said to me, 'what his mistake was, but I wanted to see whether he could find it out by himself'; and to my great surprise he continued, 'Come and have a walk round the garden'. All traces of peevishness and severity had disappeared, and for half an hour or more he became a most interesting and encouraging talker. A new reflecting telescope was just being erected in the grounds of the observatory, and he explained the uses to which it might be put and invited me, whenever I felt inclined, to come and work with it.

He then began to speak on a subject on which he evidently felt very strongly. Great preparations had been made in the previous year, and much money spent, on fitting out expeditions to observe the Transit of Venus, which had just taken place on 8th December 1874. The French Government had followed the example of other countries, but against Leverrier's advice. It was, of course, well known to astronomers that he preferred other methods of de-

termining the solar parallax, but the Government would not listen to his advice. 'Que voulez-vous?—France had recently been defeated in war, and if she did not share in international work, the Government was afraid that its action might be misinterpreted and believed to be due to sulkiness or want of funds.' But Leverrier strongly expressed his opinion that the money was all wasted, and that neither this nor the subsequent transit of 1882 would add anything of value to our knowledge. In this he proved to be perfectly right.

II. JAMES PRESCOTT JOULE (1818-1889)

I ONCE asked Joule what he felt like when he heard that one of his papers was rejected by the Royal Society. 'I was not surprised,' he answered; 'I could imagine these gentlemen in London sitting round a table and saying to each other: "What good can come out of a town where they dine in the middle of the day?"'

There are some interesting and somewhat puzzling circumstances connected with the fate of that paper, which was communicated to the Royal Society by one of its secretaries, Peter Mark Roget, on the 16th October 1840. Under the title, 'On the Production of Heat by Voltaic Electricity', it contained the account of an experimental investigation which had led Joule to formulate his all-important law, that the heat generated in a conductor by an electric current is proportional to the product of the resistance and the square of the current. The paper was read on

the 17th December, and in due course a short abstract appeared in the *Proceedings*,¹ which gave the final result arrived at, and hence secured Joule's priority. It is, therefore, not quite correct to say that the paper was rejected. The difficulty arose in connexion with its publication *in extenso*. The paper was short—it would not have taken up more than four or five pages in the *Proceedings*—and it was perhaps considered that such far-reaching results could not be proved by the comparatively few experiments conducted by Joule. Criticisms were also made on the ground that previous investigations on the same subject were not mentioned. On the 11th March 1841, the communication was committed to the archives.

A paper with the title, 'On the Heat evolved by Metallic Conductors of Electricity and in the Cells of a Battery during Electrolysis' shortly afterwards appeared in the *Philosophical Magazine* for October 1841.² It bears the date 25th March 1841, and its introductory paragraph concludes with the sentence:

'I have hoped, therefore, that the results of my careful investigation on the heat produced by voltaic action are of sufficient interest to justify me in laying them before the Royal Society.'

This remark has naturally led to the belief (definitely expressed by Osborne Reynolds in his extensive memoir on Joule published by the Manchester Literary and Philosophical Society) that the paper, as printed in the *Philosophical Magazine*, is the one declined by the Royal Society. This, however, is not the case.

¹*Proc. Roy. Soc.*, vol. iv, p. 280.

²*Phil. Mag.* [3], vol. xix, p. 260.

The difference in the title is significant. The Royal Society paper deals with solid conductors, covering only the ground which in the *Philosophical Magazine* appears as 'Chapter I', and is there followed by a second chapter, twice as long, dealing with electrolysis and adding considerably to the range and importance of the results. Even in the first part the two papers are not identical, only a few short paragraphs being unaltered—though it must be admitted that the alterations are not material. It is not at all certain whether the complete paper as it appeared in the *Philosophical Magazine* would have been declined by the Royal Society; but it is perplexing that the reference to the Royal Society was left standing in the altered and extended paper.

We cannot suppose that Joule deliberately wished to convey a wrong impression, and only one explanation seems to me to offer itself. It may be surmised that some correspondence took place in the three months between the date at which the paper was read and that at which it was committed to the archives. On being informed of the objections raised, Joule may have prepared a more complete account to be substituted for the paper originally submitted; but the Royal Society having finally declined to print the original paper *in extenso*, it is quite likely that he forwarded the amplified version to the *Philosophical Magazine*, the reference to the Society in the opening paragraph being left standing by an oversight.

It is not my desire to acquit the Royal Society of all blame, but mitigating circumstances might be urged. Joule's experiments no doubt appear conclusive to us, but the very simplicity of his experi-

mental arrangements, and the comparatively few numerical results given, may have raised doubts which were perhaps excusable. The heat generated was determined by the rise of temperature of a measured quantity of water in which a coil of uncovered wire was inserted, and no cooling correction was applied. Though Joule gave good reasons why these simplifications did not affect the result, such cavalier treatment of the minor sources of error may have shocked the academically-trained mind, as showing want of respect for the dignity of the problem. It is seldom that referees can rise to the standard of Stokes, who, in reporting on a communication by an eminent man of science possessing great intellectual powers not always assisted by clearness of expression, gave his judgment as follows: 'The first part of the paper I can understand but do not agree with; the second part I cannot understand, but as the results arrived at may be important I recommend that the paper be published in the *Philosophical Transactions*'.

Joule's later work is so intimately connected with the determination of the mechanical equivalent of heat that the importance of his investigations in other domains is apt to be overlooked. The two volumes of his published researches show that he was by no means a specialist; but only those who knew him personally are aware of the extent of his knowledge and broadness of interests ranging over nearly all branches of physics. He was a pupil of Dalton, who had refused to instruct him in chemistry before he had learned the elements of mathematics. It was perhaps in recollection of his first

teacher of science that Joule once remarked to Balfour Stewart: 'If I were a young man I would concentrate my attention on atomic weights'. When I first became acquainted with Joule, he was a little more than sixty years of age and in full vigour. The meetings of the Manchester Literary and Philosophical Society in those days will always remain in the memory of those who were fortunate enough to attend them. It was the custom then, and I believe it is still, to devote the first half-hour to a discussion on any subject brought forward by some member, spontaneously or at the invitation of the president. A regular attendant, Joule was at his best on these occasions. He also made his presence felt at the council meetings as a confirmed conservative opposed to all changes. His health began to fail about 1882, but in November 1885 he dined at my house to meet the late Lord Rayleigh, who had come to Manchester on purpose to make his acquaintance. 'I believe I have done a few little things but nothing to make a fuss about,' he said, shortly before his mental powers began to fail.

After Joule's death, I was asked by his family to examine his apparatus and instruments—mostly constructed by his own hands—and I was fortunate enough to rescue his historical thermometers, which were lying covered with dust in an old stable attached to his residence. I was thus enabled to determine the difference between the scale value of the thermometer used by Joule and that of the standard of the *Bureau international des Poids et Mesures*. It appeared in the investigation that the glass of Joule's thermometers is more suitable to its purpose than

the glass afterwards employed in England. The depression of the zero after being raised to a definite temperature is much smaller and more nearly approaches that of the hard glass used by French makers. These thermometers were presented by Joule's son to the Manchester Literary and Philosophical Society; most of the remainder of Joule's apparatus is preserved in the Physical Laboratories of the University of Manchester.

III. BALFOUR STEWART (1828-1887)

IF I were asked to name Balfour Stewart's outstanding quality as a scientific investigator, I should designate his absolute freedom from preconceived ideas both in the selection of his subjects and the manner in which he treated them. He was fond of arguing by analogy or familiar illustration. According to the writer of his obituary notice in the *Proceedings of the Royal Society*,¹ who knew him intimately, he was 'full of the most weird and grotesque ideas'. I cannot say that I ever became conscious of this in my own intercourse with him, but I only came into contact with him after his slow recovery from the injuries sustained in the Harrow railway accident of 1870. He was not a good lecturer and had difficulty in keeping order in the lecture-room—perhaps it would be more correct to say that he did not take the trouble to keep order, being too sympathetic with youthful exuberance. In the laboratory he was an inspiring teacher, and it would not be an exaggeration

¹*Proc. Roy. Soc.*, vol. xlv1 (1889), p. ix.

to say that he was the godfather of much of our modern science, for both Poynting and J. J. Thomson received their first lessons in physics from him.

Balfour Stewart's family intended him for a mercantile profession, and at the conclusion of his university studies he went into business in Leith, and later spent some time in Australia, about the year 1855. But science had laid its spell on him, and he soon returned to Edinburgh, where he became assistant to J. D. Forbes, who had considerable influence in shaping his mental outlook. It was during the years he spent at Edinburgh that the work on the equilibrium of temperature radiation was begun and, in its essential features, completed. In 1859, Balfour Stewart was appointed superintendent of the Kew Observatory, which was then managed by a committee of the British Association under the presidency of J. P. Gassiot. All went well until the organization of the meteorological service of the country was transferred from the Board of Trade to a committee of the Royal Society, consisting of eight Fellows, with General (afterwards Sir) Edward Sabine as chairman. The expenses were covered by a Treasury grant of £10,000.

Trouble soon arose, and, I think, both for their historical interest and in justice to Balfour Stewart's memory, an account of the incidents which ultimately led to his retirement from the direction of Kew Observatory should be given. I am enabled to do so on the evidence of the relevant documents, which came into my keeping after Balfour Stewart's death. When the Board of Trade had agreed to the request of the Meteorological Committee for the

assistance of a scientific secretary Balfour Stewart was appointed to that office, understanding that he was to be the scientific adviser of the Committee; but when afterwards he was designated simply as 'Secretary to the Committee' he disliked the omission of the qualifying word 'scientific', but acquiesced. 'Nevertheless,' he declared in a printed statement from which I quote, 'I continued to understand that it was my special duty, in case I might see anything defective in the scientific position of the Committee, to urge them to amend it'.

Differences of opinion soon arose between Sabine and Stewart with regard to the method of reducing meteorological observations, and his repeated requests for clerical assistance were declined by the Committee. The crisis came when Balfour Stewart directed General Sabine's attention to what he considered to be an error in an unconfirmed minute of one of the meetings of the Meteorological Committee. Stewart's account of the interview which took place concludes with the following statement: 'He [General Sabine] assured me there was no mistake and added in answer to a question that he, *on his own responsibility*, had authorised the preparation of such of those results at the central office as had not been authorised by the Committee'. To use a familiar term, Sabine admitted having cooked the minutes. At the same time, Balfour Stewart was privately told that the chairman was much opposed to his scheme of reducing observations, and that there was not much chance of its being adopted. With regard to the merits of the proposed scheme there can be little doubt. Stewart had submitted it

to a few independent men of science and the reply of the Astronomer-Royal, Sir George Airy, may be given *in extenso*.

'I have read with much satisfaction the paper of your Remarks on Meteorological Reductions, etc., especially with reference to Vapour. I do hope that by going on thus you may make Meteorology a science of causation, and raise it from its present contemptible state.

'I have often thought that much may be gained by ascertaining at what rate aqueous vapour disseminates itself through air, and should long ago have made experiments, but that I want a hygrometer of sufficient delicacy. I then thought of suggesting it to the Kew Committee. Your paper restores the interest in my old intention, and I think I shall write to Mr. Gassiot.'

Lord Kelvin (then Sir William Thomson) also gave his full approval, writing:

'I believe the plan you propose is adapted to bring out information of the most valuable kind, from observations which, until reduced on some such plan, might be accumulated indefinitely without any practical benefit.'

Stewart was naturally distressed by the manner in which his advice was set aside, no scientific grounds being given. Fearing that the anxieties of his office might affect his health, he wrote a letter to the chairman of the Committee resigning the secretaryship. He also tendered to Mr. Gassiot his resignation as superintendent of Kew on the ground that the two bodies were closely bound together, but declared at a meeting of the Meteorological Committee that he gave up this office with extreme reluctance. He was asked, in an interview with Mr. Gassiot, whether there was anything that would induce him to withdraw his resignation, and was given to understand

that Sabine would wait to hear the condition under which he would continue office before taking further steps. Stewart then wrote a letter explaining the difficulties in which he was placed owing to insufficient help in the numerical work and stating that, if some assistance were given him in the preparation of the preliminary reductions of the observations, he desired to withdraw his letters of resignation. The reply was as follows:

‘I regret that you were so determined to send in your resignation. It appears Sir Edward Sabine has written to Bombay, where Colonel Smythe is, and nothing can be done until the reply comes.’

Sabine’s letter referred to, offering the appointment to another man, was posted on the day of the interview with Gassiot, and—as Stewart points out—before his resignation had been formally accepted by the respective committees.

The obstinacy with which Sabine pressed his own opinion is perhaps intelligible in a man who was then eighty-one years old, but there is nothing to say in extenuation of the want of generosity exhibited in the following letter to Stewart:

‘My not having responded to your request more promptly and more fully, has not arisen from want of solicitous thought, and wish to serve you.

I feel assured that if your work at Kew had ere now been crowned by the looked-for completion of the account of the results of the long and invaluable series of magnetic observations, the later and longer portion of which were under your own superintendence, you might, and I might, have appealed triumphantly to such an evidence, not only of what you were capable of doing, but of what you had done, as placing you in a pre-eminent position.’

The letter is dated the 31st May 1870, and was presumably written in answer to a request for a testimonial in view of Stewart's candidature for the chair of physics at Owens College, Manchester. With regard to the implied complaint, I have before me the copy of a letter written by Balfour Stewart, from which it appears that he was waiting, previous to 1865, for the details of the observations which were in Sabine's possession. In spite of his repeated requests they were never sent to him. He could scarcely be expected to start on an extensive work of reductions before he had the whole material before him.

Balfour Stewart's greatest scientific success was achieved in his researches on the equilibrium of radiation in an enclosure of uniform temperature, which led to the enunciation of the connexion between radiation and absorption. His omission to drive home convincingly the application of his results to the explanation of the dark Fraunhofer lines was, in his own later opinion, due to a want of chemical knowledge. Looking at a flame coloured with common salt, and believing that the yellow colour of the flame was due to luminous sodium chloride, he was disappointed to find that a plate of rock-salt did not sensibly absorb the emitted light.

Stewart had the faculty of recognizing the importance of problems, even when he had not the power theoretically or experimentally to make much headway in their solution. He saw, for example, the need of studying the temperature equilibrium in an enclosure which contained moving bodies, both radia-

tion and absorption being affected by the Doppler effect. But instead of looking for the solution of the difficulty—as was subsequently done by Wien—in an adjustment of the law of radiation as depending on temperature and wave-lengths, he imagined that the equilibrium of radiation was actually destroyed, the second law of thermodynamics being satisfied by the mechanical forces necessary to maintain the motion. In conjunction with Tait he designed an experiment in which a disc was kept rotating *in vacuo*, and believed he had actually discovered an increase of the temperature of the disc. The success of the experiment depended, of course, on the perfection of the vacuum, and Stewart shared the erroneous belief of the time that a perfect so-called chemical vacuum could be obtained by filling a vessel with carbonic acid, exhausting with an ordinary air-pump and absorbing the remnant of the gas with caustic potash.

I have remarked that Stewart's mind worked a good deal by analogies. He was fond of one particular illustration. Imagining a moving train and a body of men cutting across by jumping into it from one side and out of it at the other, it is clear that the train will gradually lose speed. The idea was applied to special cases and suggested several experiments to him. I joined him in one of these, in which an electric current was passed through water and an electromotive force applied at right angles to the current. Stewart hoped to detect some interference of the currents with each other. The same type of reasoning was in his mind in contemplating possible mechanical effects of radiation. I believe that at the bottom

of these speculations was some prophetic glimmering that a propagation of energy always implies a propagation of momentum. The weak feature of his work was that he often designed and tried experiments of a refined nature with appliances which were insufficient, and even at that time might have been improved upon; such were his attempts to discover a screening effect of metals on gravitation, and a change of mass by chemical combination. In the latter experiments, in which the combining bodies were mercury and iodine sealed up in a glass bottle, J. J. Thomson, who assisted him, nearly lost his eyesight through an explosion.

Stewart was indefatigable in his work. While the days were spent in the laboratory, he pursued his statistical investigations on magnetic and solar phenomena in the evenings. Some of these researches are published under the joint names of himself, Warren De la Rue and B. Loewy. Loewy, though I believe he had some claim to scientific knowledge, was chiefly employed as an assistant, paid for carrying on the numerical work, which was often heavy. I believe that De la Rue's share consisted in supplying the funds. One morning Stewart arrived at the laboratory in a great state of distress. In looking over the proofs of a paper accepted for the *Philosophical Transactions*, he had found that the numerical work was all wrong. Loewy had, in fact, saved himself trouble, and evolved the results out of his inner consciousness. The paper had to be withdrawn, and De la Rue paid a substantial sum for the expenses already incurred in printing. Neumayer, who was at the time director

of the *Sternwarte* at Hamburg and on whose recommendation Loewy had been engaged, told me afterwards that he had sent for Loewy and charged him with manipulating the results. Loewy admitted doing this, but excused himself on the ground that, while he had originally worked honestly, Stewart had never checked his results, so that the blame must be his.

Some reference should be made to a little volume, *The Unseen Universe*, published in 1875, and intended to reconcile science with revealed religion. It appeared anonymously at first and, though probably forgotten now, it created a sensation at the time, and ran rapidly through many editions, in the later ones of which the authors' names—Balfour Stewart and P. G. Tait—were given. Referring to Tait's contribution, Stewart told me that when he first approached him, suggesting a joint publication, his consent was subject to the condition that Stewart should write the book, while he would make himself responsible for the preface. When this was agreed to and the manuscript of the preface arrived, Stewart was amused to find that it was almost entirely taken up with an attack on John Tyndall, who was Tait's *bête noire*. It had to be re-written, and, to judge from internal evidence, I should surmise that not much more than the first paragraph was Tait's work. I am under the impression, nevertheless, that Tait's share in the book was not negligible, and that, though he acted mainly in an advisory capacity at first, he made substantial additions in the later editions.

Towards the close of his life Stewart became much interested in so-called spiritualistic phenomena, but

he always insisted—sometimes with great vigour—on his disbelief in messages from the dead, which were contrary to his religious convictions. With regard to unexplained phenomena, in which fraud may possibly have a share, it must be said that Stewart's confiding nature rendered him quite unfit to act as a judge. He was like a child in these matters. A certain personage near Buxton—so far as my recollection goes, a clergyman—wrote to Stewart about his powers of second sight, which enabled him to find a hidden object or name a card drawn at random out of a pack. Stewart went to see him several times and was impressed. 'What is most remarkable,' he told me after the second or third visit, 'is that the power can be transferred to others. There is a servant girl in the house who, after a stay of a few weeks, has acquired it and can now name an unseen card just as well as her master.' Not a shadow of suspicion had crossed his mind.

Stewart's conversation was always suggestive and sometimes witty. The Principal of Owens College (Dr. J. G. Greenwood) had a habit of writing letters to the professors when he had any fault to find. These always began with some complimentary remarks, the sting being reserved for the concluding sentence, or frequently for a postscript. 'Every billet has its bullet' was Stewart's comment after receiving one of these communications.

IV. GUSTAV ROBERT KIRCHHOFF (1824-1887)
AND ROBERT WILHELM BUNSEN (1811-1899)

IN the controversies that excited at one time a good deal of feeling with regard to the part played by different men of science in establishing the principles of spectrum analysis, some confusion was caused by the ambiguous meaning of the word 'analysis'. The term may apply to the separation of the spectrum into its constituent homogeneous radiations, or it may denote a method to identify the constituents of a chemical compound by the light it emits when raised to incandescence. To avoid the ambiguity, I introduced in 1882 the word 'Spectroscopy', to indicate the physical side of this branch of science. With regard to the use of the prism as an instrument of chemical analysis, there can be little doubt that Kirchhoff and Bunsen first demonstrated its practical importance, though Wheatstone had clearly indicated its possibility.

I worked for one year with Kirchhoff at Heidelberg (1872-73). Those were not days of extensive and well-equipped laboratories. Next to Kirchhoff's private study, in the building which served as his residence, one room only was available for advanced work. Its chief occupant was Lippmann, who was working at his capillary electrometer. My table was by the side of his, and having placed myself entirely at Kirchhoff's disposal, he asked me to test an instrument he had devised for the study of metallic reflexion. Nothing came of it, partly because the instrument did not prove suitable for the accurate study of elliptic polarization, and partly because

my measurements were not very good owing to my astigmatism, which had not at that time been recognized. The only other advanced student was Kamerlingh Onnes, who was experimenting with a pendulum designed to demonstrate the turn of the plane of vibration due to the rotation of the earth. He had to work in the lecture-room next door. There was only one other room, and that was used for elementary exercises. One exercise was set aside for each week, and every student—there were about eight altogether—had a morning or afternoon assigned to him for carrying out the experiment. There was one weekly lecture in which the results were criticised and the succeeding exercise explained.

During his frequent visits to the laboratory, Kirchhoff was quite ready to discuss the burning questions of the day. His general outlook on the future progress of science was that, so common at the time, which regarded the main facts of nature as established, leaving room only for the elaboration of their correlations and greater accuracy of measurement.

During my stay at Heidelberg, I was anxious to repeat an experiment I had previously performed on the spectrum of nitrogen. There was no glass-blower in Heidelberg and no means of obtaining a Geissler tube. Kirchhoff, to whom I appealed, advised me to consult Bunsen, who offered to let me use his laboratory, where I could find the necessary appliances. I had to confess that I was not sufficiently expert in glass-blowing to make the tube myself. He seemed rather amused, took me to a little room and spent the next half-hour at the blow-pipe.

When the tube was ready, further difficulties arose. Bunsen gave me a very inefficient induction coil and insisted on my using a bichromate battery; but he would not allow the zinc plates to remain in the solution for more than two or three seconds, watching me all the time. I could not get a proper start and had to give up the experiment.

There are always innumerable stories about Bunsen illustrating his absent-mindedness and simplicity of character. Many of them will be found in Roscoe's *Life and Experiences*.

I attended Bunsen's elementary lecture course, which began at seven o'clock in the morning during the winter and at six in summer; but one had to be in the lecture-theatre well in advance of the hour fixed, because the time was taken from a very erratic clock in this room. Whenever Bunsen was ready to start, he sent his assistant in to set the clock, at six or seven as the case might be, beginning the lecture sometimes a quarter of an hour too early or too late by the real time.

There could be no greater contrast both in appearance and manner than that presented by the two men; Kirchhoff, sharp-featured and always correct and precise; Bunsen, with the appearance of a prosperous farmer, and a somewhat cynical but at the same time good-natured smile. New discoveries almost worried Kirchhoff: they amused Bunsen. The effect of light on selenium happened to be first published when I was at home on a holiday, and on returning to Heidelberg I mentioned it to Kirchhoff. His reply was: 'I should not have believed that such a curious fact could have remained undiscovered

until now'. Kirchhoff's lectures were prepared with extreme care and delivered with precision. He is reported never to have missed one during the tenure of his professorship at Heidelberg, but the record was certainly broken on one occasion. 'I regret to announce,' he said on a certain Thursday at the conclusion of one of his lectures, 'that circumstances prevent my meeting you to-morrow.' The 'circumstances' were that he was going to get married, and the honeymoon lasted from Friday till Monday, when he was at his desk again.

When Kirchhoff and Bunsen had retired and were nearing the end of their lives—one at Berlin and the other at Heidelberg—I occasionally went to visit them. Kirchhoff's interests were confined to the days that were gone. He admired Maxwell for his work on the kinetic theories of gases. 'He is a genius,' he said, 'but one has to check his calculations before one can accept them.' He admired Lord Kelvin for his vortex theory of matter. 'I like it,' he remarked, 'because it excludes everything else,' and he added with a sigh: 'If only it could explain gravitation'. Bunsen liked to talk about new ideas. 'Tell me all about the experiments of Hertz,' was his first remark on one occasion; and in spite of his almost complete deafness, he had a way of understanding when the subject interested him.

It may be worth while to record the scepticism of Bunsen with regard to the chemical identity of the diamond and carbon. He considered the evidence to be insufficient, depending in great part on a single reaction of the gas produced in the combustion of the two bodies. A more convincing test was the demon-

stration that equal weights of the two bodies produced equal weights of the products of combustion; but all depended here on the accuracy of the measurement, which probably was not very great. My information came from Sir Henry Roscoe, who repeatedly alluded to it in conversation. Later, when engaged at the Cavendish Laboratory on the spectrum of oxygen, I took the opportunity of placing a diamond inside a platinum spiral in an oxygen vacuum, and raising the spiral to a red heat by means of an electric current. The characteristic spectrum of an oxygen compound of carbon at once appeared, leaving no doubt as to the nature of the diamond.

If I were asked to name the quality which is most characteristic of Kirchhoff's scientific achievements, I should point to its precision; I mean precision both in the clear statement of a problem as well as in the process which led to its solution. But this quality, much as it added to the value of his published work, detracted, in my opinion, from his efficiency as a teacher. His lectures were read out from carefully prepared manuscripts and he risked losing touch with his hearers, only the most gifted of whom could follow with sufficient rapidity the successive steps of his reasoning. This led to a copious taking of notes, which had to be deciphered subsequently. I cannot help contrasting, in this respect, Kirchhoff with the mathematician, Königsberger, whose lively delivery and power of remaining in mental touch with his audience kept up the students' interest and helped the understanding. To put it briefly, Kirchhoff's weapon of teaching was 'accuracy of exposition', while that of Königsberger was 'inspiration'.

V. LUDWIG BOLTZMANN (1844-1906)

I DID not know Boltzmann intimately, but can tell of some incidents in his life, and quote from passages in little-known publications, which mark his impulsive and vigorous character, and illustrate some features of his personality that would be missed by anyone acquainted only with his scientific writings. As a young man twenty-six years old, who had only published one or two minor papers, Boltzmann called on Königsberger, then professor of mathematics at Heidelberg, and mentioned incidentally that he had discovered an error in one of Kirchhoff's mathematical papers. Königsberger told him that this was a good opportunity of becoming personally acquainted with one of the great men of the time. 'Call on Kirchhoff,' he advised. 'Lead the conversation to the subject, and explain the nature of his error.'

Boltzmann acted with characteristic impetuosity. Within an hour Kirchhoff, who always took a great pride in his accuracy, came rushing into Königsberger's room in a state of extreme agitation. 'A most distressing thing has just happened to me,' he exclaimed. 'A young man, of whom I know nothing, enters my room and, before he has time to shut the door behind him, calls out: "Herr Professor, Sie haben einen Fehler gemacht!"'¹ I give the tale on Königsberger's authority.

Boltzmann made his reputation during sixteen quiet years at Graz, but it was a grief to him that his lectures did not attract a more numerous audience, and he was always looking out for a university

¹'Professor, you have made a mistake.'

where budding mathematicians were as plentiful as chemists or lawyers. He went to Munich, and next to Vienna, but still not being able to satisfy his ambition he was drawn again to Germany, the country towards which he had strong political leanings. He received an offer of a professorship at Berlin, and I was informed by one in a position to know that the faculty of science at that University received a series of telegrams and letters, few of the latter being dated, some accepting, some refusing; and no one knew in what order they were dispatched. Ultimately, the negotiations were broken off, and Boltzmann went to Leipzig, but he soon longed to return to Vienna. That University would have welcomed his return, but the Emperor declined to call him back, on the ground that an Austrian subject who had accepted foreign service was disqualified from ever again finding employment in his dominions. Herr von Hartel, who was then Austrian Minister of Public Instruction, told me how for a considerable time he stood helpless between two fires: on one side, the insistence of the University which wanted Boltzmann; on the other, the obstinacy of the Emperor who remained firm in his refusal. At last von Hartel decided to make a final effort, and asked the Emperor for permission to put a hypothetical question. This being granted, the question put was: 'If your Majesty's favourite ballet dancer were to run away, and after a year's absence wanted to return, would you have her back?' The Emperor admitted that perhaps he might.

'I beg to submit,' said the Minister, 'that Boltzmann is to the University what your favourite ballet dancer is to you.'

Francis Joseph laughed and gave in.

I do not tell the story merely as an amusing episode, but because the image of Boltzmann's ungainly figure trying to practise ballet steps recalls to my mind the occasions—fortunately rare—when Boltzmann indulged in humorous writing. He had travelled much, visiting America, Constantinople, Athens, Smyrna, and Algiers, and in one of his writings tells us how he had always declined to publish an account of his experiences, but that after returning from a lecturing engagement at the University of California at Berkeley, the temptation proved too strong, and an article appeared under the title of 'Reise eines deutschen Professors ins Eldorado'.¹ His jokes are driven into us with hammers. Eating and drinking, followed by drinking without eating, form a favourite subject, because to him—as he says—the most important consideration in travelling is to keep one's digestion right. But he might have spared us the allusions to the poisonous effects of pure water and the boast that his otherwise good memory for figures fails when he tries to remember the number of glasses of beer he has imbibed! The astonishing part of his recital is, however, its want of accuracy. In an account of a dinner party given in his honour at the country seat of a wealthy lady near San Francisco, he tells us how it began with blackberries, which were followed by porridge, 'an indescribable paste made of oatmeal, which might be used for fattening geese in Vienna were it not that the geese would refuse to eat it'. The context makes it clear that Boltzmann is referring to dinner, but he has

¹L. Boltzmann, *Populare Schriften* (1905), pp. 403-435.

obviously added some dishes offered him at breakfast. On scientific matters also he falls into error, as when he tells the reader that the moons of Mars were discovered at the Lick Observatory.

In great contrast with this heavy and vulgar joking, the other matter contained in the volume of popular writings shows us Boltzmann as a highly cultivated man, enthusiastic about poetry, fond of music, not averse from expressing an opinion on art, and with a leaning towards metaphysical speculations. An article on flying, written in 1894, is specially interesting, and the following passage shows considerable foresight:

'It is scarcely doubtful that a dirigible air-ship would create an expansion of intercommunication compared with which that due to the introduction of railways and steamers is negligible. Our armies of to-day would be as helpless against the dynamite thrown down from iron flying-machines as those of Rome would have been against breechloaders. The customs regulations would either have to submit to unthought-of alterations or to be abolished altogether.'¹

Astonishing, as coming from an Austrian, is the German chauvinism to which Boltzmann occasionally gives expression. It appears in his article on aviation, and in a passage in the description of his Californian journey. After criticising the Berlin Academy and expressing regret that since the death of Helmholtz and other distinguished Germans American students had preferred to study in Cambridge and Paris rather than in Berlin, he added that the United States, and in fact the whole world, would suffer in consequence.

¹The paper is reprinted in the *Populare Schriften*, pp. 81-91.

On scientific matters his judgment is nearly always fair and uninfluenced by national feeling, at any rate so far as Great Britain is concerned. Here is an example of his style of writing when he is carried away by his subject:¹

'A mathematician will recognise Cauchy, Gauss, Jacobi, Helmholtz, after reading a few pages, just as musicians recognise, from the first few bars, Mozart, Beethoven or Schubert. A supreme external elegance belongs to the French, though it is occasionally combined with some weakness in the construction of the conclusions; the greatest dramatic vigour to the English, and above all to Maxwell. Who does not know his dynamical theory of gases? First the variations of the velocities are deployed in majestic array; next enter from one side the equations of state, from the other, the equations of central motion. Higher and higher surges the chaotic flood of formulæ, until suddenly the four words resound: "Put $n = 5$," and the malignant demon V vanishes, just as a wild overpowering figure in the bass may suddenly be reduced to silence. As if by a magic wand, an apparently hopeless confusion is reduced to order. There is no time to explain why one or the other substitution is made; let him who does not feel it in his bones put away the book. Maxwell is no composer of programme-music who has to preface his score by a written explanation. Obediently, his formulæ deliver result upon result, until we reach the final surprise effect. The problem of the thermal equilibrium of a heavy gas is solved, and the curtain falls.

'I remember still how Kirchhoff, discussing this memoir with me, made the remark: "This is the way to deal with gas theories."'

It is not perhaps fair to examine this passage too closely, as a certain amount of poetic licence must be forgiven—but Maxwell did not write: 'Put $n = 5$ ';

¹Boltzmann, *loc. cit.*, p. 73.

he wrote: 'It will be shown that we have reason from experiments on the viscosity of gases to believe that $n = 5$ '.¹ Twenty-one words instead of four; but scientific accuracy has no chance when rhetorical effect is in danger, as the late Lord Rayleigh remarked to me when I criticised a statement of a distinguished relative of his.

Shortly after his final return to Vienna, Boltzmann committed suicide. With him passed away a man of great intellectual power and a fascinating personality. His predilection for Schiller's poetry indicates a strain of morbid sentimentality, and, if his humour was somewhat primitive and his technique crude, he paid dearly for his disappointments in life.

VI. SAMUEL PIERPONT LANGLEY (1834-1906)

LANGLEY's invention of the bolometer, and his pioneer work in the construction of the flying machine, are achievements sufficiently great to ensure a reputation which will outweigh the recollection of defects due to an exaggerated consciousness of dignity, accompanied by a marked inability to see the humorous side of things. I first met Langley on the occasion of the total solar eclipse in August 1878, when he established an observing station on the top of Pike's Peak in order to obtain, if possible, a measure of the thermal radiation of the solar corona. Unfortunately, he suffered severely from mountain sickness, and had to be carried down before the day of the eclipse.

¹*Philosophical Transactions of the Royal Society*, vol. clvii, p. 60.

In the following year, Langley visited England and expressed to me the desire to become acquainted with Clerk Maxwell. I was working at the Cavendish Laboratory at the time, and was able to assure him that Maxwell would be interested to meet him, as he had, in my presence, referred in very eulogistic terms to a method proposed by Langley to eliminate the personal equation in transit observations. Clerk Maxwell was just then editing Cavendish's scientific manuscripts, and conscientiously repeated every experiment that was described in them. He was specially interested in the method which Cavendish had devised for estimating the relative intensities of two electric currents, by sending the currents through his own body and comparing the muscular contractions felt on interrupting the currents. 'Every man his own galvanometer,' as Maxwell expressed it. When Langley arrived, I took him to the room where Maxwell stood in his shirt-sleeves with each hand in a basin filled with water, through which the current was laid. Enthusiastic about the unexpected accuracy of the experiment, and assuming that every scientific man was equally interested, he tried to persuade Langley to take off his coat and have a try. This was too much for Langley's dignity; he did not even make an effort to conceal his anger, and on leaving the laboratory he turned round and said to me: 'When an English man of science comes to the United States we do not treat him like that.' I explained that, had he only had a little patience and entered into the spirit of Maxwell's experiment, the outcome of his visit would have been more satisfactory.

As an experimenter Langley takes a high rank,

though the numerical results he derived were sometimes based on calculations that were not entirely free from defects. This led him occasionally to an optimistic judgment of their accuracy. In sending out an assistant to repeat his measurement of the so-called solar constant, which expresses the total solar radiation in certain units, his final words to him were: 'Remember that the nearer your result approaches the number 3, the higher will be my opinion of the accuracy of your observations'. The assistant, who since then has himself attained a high position among American men of science, was fortunately a man of independent judgment, and skilful both in taking and reducing his observations, with the result that the number 3 is now altogether discredited.

VII. OSBORNE REYNOLDS (1842-1912)

WHENEVER I hear of a man who is described as being lovable, the figure of Osborne Reynolds rises up before me; and yet I doubt whether on a casual acquaintance or in official intercourse that adjective would have suggested itself. In ordinary conversation he often took a cynical view of things; he was obstinate in adhering to his own opinion, absolutely uncompromising, and sometimes a little hasty in imputing selfish motives to his opponents. But the discordant elements of his character were fused together by an almost primitive simplicity of mind, and after closer acquaintance few could resist the charm of his strong personality.

His loyalty to friends and colleagues knew no bounds. In 1883, Mr. E. J. Stone, formerly Astronomer Royal at the Cape of Good Hope and, at the time, president of the Royal Astronomical Society, made a series of communications to the Society in which he claimed to show that the discrepancies between the lunar tables and the observed position of the moon had no reality, but were only natural consequences of the changes which had, from time to time, been introduced in the adopted mean solar day; and, in particular, that the errors of Hansen's tables of the moon were due to the adoption of Leverrier's solar tables by the *British Nautical Almanac*. The matter was of the highest importance, as it affected our fundamental unit of time. The subject is intricate and full of pitfalls, but clear-headed men like Adams, Cayley, and Newcomb all came to the conclusion that Stone's assertion could not be maintained. I must have mentioned the matter to Osborne Reynolds. He had no special interest in astronomy; in fact, he knew very little about it, but he had been a fellow of Queens' College, Cambridge. So had Stone, and that was sufficient reason why Stone should be right. When I quoted Cayley and Adams it made no impression. Reynolds maintained the general thesis that when a man of established reputation has the whole scientific world against him, it is quite certain that the man who stands alone is right. After considering the subject for a few days he came to me and said: 'I have gone into the question, and I remain convinced that Stone is right'. Again, two days later, he expressed the same opinion. Another week passed and he recanted, ad-

mitting that Stone was wrong. But he had spent more than a week on a new, and probably uncongenial, subject in the forlorn hope of being able to support a friend.

An interesting chapter in the history of science could be written on the hampering effect of knowledge that is either deficient or too complete. Ignorance may lead astray, but perfect knowledge often acts as a brake and stops the car when a reckless spurt would take the driver into new territory. For the moment I am thinking of the early history of the radiometer, though this is not perhaps the best example that could be chosen. The manner in which Crookes was led from certain irregularities of weighing to the construction of his interesting little instrument was wholly admirable, and some of the steps in the research, such as the improvement of air-pumps, marked considerable advances, while other incidental results are also of permanent value. But it is permissible to ask whether anyone wholly conversant with the properties of gases at low pressures, and therefore able to anticipate the effect discovered by Crookes, would have taken all the trouble to spend two years in demonstrating it. Even if Crookes had been familiar with Maxwell's theory of radiation pressure, a more perfect acquaintance with the facts would have made it clear that there was no immediate hope of verifying it experimentally until the methods of obtaining high vacua were improved to a degree not dreamt of in those days.

There can be no doubt that the driving power of Crookes's work was the hope of discovering a new property of radiation. The first communication read

before the Royal Society in December 1873¹ concludes with the following statement: 'In the radiant molecular energy of cosmical masses may at last be found that "agent acting constantly according to certain laws", which Newton held to be the cause of gravity'. He modified his views later, and ascribed the effect to light even 'where there is no heat' (*Nature*, vol. xii, p. 125).

Reynolds recognized that the apparent repulsion could be explained without the help of unknown forces, in the belief, at first, that they were due to condensed moisture evaporating under the influence of thermal radiation; but he soon replaced this view by the now generally accepted theory. Johnstone Stoney had put forward similar ideas which, nevertheless, differed in essential points.

During the winter of 1873-74 I suggested to Reynolds, as I had done to others, that the main question whether the repulsion was caused by internal or external forces could be solved in a very simple manner by the reaction on the containing vessel. When I returned in November 1875 from the Siamese eclipse expedition, I found the controversy still raging, but no one had taken the trouble to try the crucial experiment. I was reluctant to do so myself, as a number of persons were working on the subject, and I have perhaps an exaggerated objection to cutting into what I consider to be other people's work. I repeatedly spoke to Reynolds about it in the hope that he would take the matter up. One evening, after lecturing hours, while I was working alone in the Physical Laboratory, Osborne Reynolds entered the room and said: 'I

¹*Proc. Roy. Soc.*, vol. xxii, pp. 37-41.

want you to do that experiment you spoke of, and to do it now. I have got everything ready for you.' I went with him to the lecture-room. We suspended the radiometer with an attached mirror, and, at the first trial, it behaved as it should. The vessel swung round as soon as the light fell on the blackened surfaces, and returned to its position of rest when the rotation of the vanes had reached the steady state. Reynolds would not listen to the proposal of a joint communication, and my paper appeared in due course in the *Philosophical Transactions*.¹

In his writings, as in his speech, Reynolds was difficult to understand. His brain seemed to work along lines different from those of the majority of us. He looked upon all things in an original manner, and the education of his children was one of them. I once found him playing with his little son, and nothing seemed to give him greater pleasure than when the boy did the opposite thing to that which he was asked to do. 'Come here,' said Reynolds, and when the child went further away Reynolds was delighted, interpreting the act as showing independence of spirit. The incident made a great impression on me.

In his later years Reynolds had difficulty in finding the right word, using sometimes one that had the opposite meaning to that required. This failing ultimately developed into regular aphasia.

The value of his scientific work is admirably described in the obituary notice published by the Royal Society.² It may be added that though his theory of the construction of the universe, on which he con-

¹Vol. clxvi, pp. 715-724.

²*Proc. Roy. Soc., A.* vol. lxxxviii (1913), p. xv.

centrated his whole strength at the end of his scientific life, received little support, it may yet find its place in reconciling the old and new physics.¹

In his lectures Reynolds was often carried away by his subject and got into difficulties. Some humorous incidents are related with regard to the manner in which he got out of them. He was once explaining the slide-rule to his class; holding one in his hand, he expounded in detail the steps necessary to perform a multiplication. 'We take as a simple example three times four,' he said, and after appropriate explanations he continued, 'Now we arrive at the result; three times four is 11.8'. The class smiled. 'That is near enough for our purpose,' said Reynolds. It may be imagined that the average student was often puzzled; but, nevertheless, the number of scientific engineers of high standing that he trained is a testimony to his teaching power, when he had the right material with which to deal. That power was not one of imparting knowledge but rather of stimulating thought.

Not long ago a representative of the University of Manchester lectured in the United States. At the conclusion of the lecture a gentleman stepped out from the audience, and, addressing the lecturer, said: 'I understand that you come from Manchester. I owe all my success in life to Osborne Reynolds, and I ask you to accept a cheque for the benefit of the University as a sign of gratitude.' No one could wish for a higher testimonial than that.

¹See his Rede Lecture for 1902, *On an Inversion of Ideas as to the Structure of the Universe*, and his *Sub-Mechanics of the Universe*, published for the Royal Society (1903).

VIII. THREE GÖTTINGEN PROFESSORS,
 WILHELM EDUARD WEBER (1804-1891),
 FRIEDRICH WÖHLER (1800-1882), ERNST
 FRIEDRICH WILHELM KLINKERFUES (1827-
 1884), AND AN ADVENTURE

WHEN I went to spend two months at Göttingen in the summer of 1874, Wilhelm Weber had just retired from the professorship. I doubt whether the present generation of physicists are familiar with his work, though there was a time when electricians talked about weber-currents, galvanic-currents, and faradic-currents as if they were different things. I feel sure, however, that chemists have not forgotten Friedrich Wöhler, who occupied the chair of chemistry at the University of Göttingen during forty-six years. Both men were Copley medallists. Wilhelm Klinkerfues stands on a somewhat lower level of distinction, though he did meritorious work, was amongst the first to recognize the importance of Doppler's principle, and discovered six comets.

When Weber was first appointed to the chair of physics at Göttingen in 1831, that town formed part of the kingdom of Hanover. When the connexion with England was finally severed in 1837 by the accession of Ernest Augustus, Duke of Cumberland, to the throne of Hanover, the new king repudiated the constitution which the country had enjoyed for a considerable time. Seven professors of Göttingen University protested against this autocratic action and had to leave the country. They included, besides Wilhelm Weber, his brother, the physiologist, and Jacob Grimm, the writer of fairy tales. Weber

was offered a chair at Leipzig, where he remained until he was reinstated at Göttingen in 1849. In 1874, at the age of seventy, he was still full of vigour. A short man with a clean-shaven, round, and smiling face, he was ready to discuss the current scientific problems with freedom and sagacity. I much enjoyed the two occasions on which he invited me to join him in his walks along the walls of old Göttingen.

A man's mentality often finds significant expression in the way in which he shakes hands. Kopp, of Heidelberg, used to raise the proffered hand slowly to the level of his short-sighted eyes, and keep it there for a few seconds as if wondering what to do with it. Weber raised his arm vertically upwards and swung it down in a swift and forcible sweep, as if he really meant it. I was told that, under the influence of Zöllner, Weber had taken up spiritualism, but I never knew that side of him.

In contrast with Weber, Wöhler seemed to live entirely in the past. I only spoke to him a few times. He was fond of relating old reminiscences, and his conversation generally ended in a recital of his personal ailments. I can only remember one of his tales. He had an official residence above his laboratory, and one night he was awakened by the noise of an explosion. He gave a graphic description of how, with a candle in his hand, he went down to see what had happened. At the point of opening the door, he hesitated. Could there still be some explosive gases hovering round the laboratory? He blew out the candle and entered the room, and found indeed that he had narrowly escaped losing his life by a second explosion. There is not much in this story, but

Wöhler seemed to be very proud of this testimony to his presence of mind.

I had called on Wöhler at the express wish of Roscoe, who sent him, through me, a small flask filled with a vanadium salt. Wöhler was delighted, and could scarcely believe that this was for him to keep and not only to look at. He had been doing some work on vanadium himself with only a small quantity at his disposal, and whenever I met him afterwards he always expressed surprise that Roscoe could spare so much of it. The day following my first call, on returning to my lodgings, I found a visiting card with his name neatly written on it.

Klinkerfues was a man of different type and calibre. He generally took his meals in common eating-houses, surrounded by students, and occasionally I was one of the party. He used to entertain us with inferior jokes. One example must suffice. 'I have always had a remarkable memory for numbers,' he said. 'At school in the history lesson I could remember every date. Unfortunately, I always forgot what happened on the dates.' It was said of him that when he received his salary he spent his money lavishly, eating and drinking in the most expensive places, and when he had spent nearly everything he lived mainly on sausages and beer. His duties sat lightly upon him. By a general rule of the German universities, a professor is not obliged to lecture to less than three students (*tres faciunt collegium*), and when at the beginning of term one of them called to inscribe himself for the course which had been announced, Klinkerfues told him that he would have to find two others who also desired to attend. It was

aid that, if half an hour later another man came with the same request, he received the same answer, and it was only when the term was in full swing that the disappointed students became known to each other. I do not vouch for the story. The fact that the fees went to the professors, and the well-known impecuniosity of Klinkerfues, speak against it. He ultimately ended his life by committing suicide.

There was another professor at Göttingen, a philosopher and theologian, with whom I had some acquaintance. When I called on him, he warned me that the life in Göttingen was different from that at Heidelberg. The students were more formal, and inclined to take offence if one did not conform with their codes of behaviour. It was not many hours before I had occasion to regret that I did not attach more importance to his warning. On the evening of my visit to him I went to some open-air place of entertainment where I met an acquaintance who was accompanied by three other students. He asked me to join his party, but I told him that I was on my way home. Ultimately, he persuaded me to sit down for a few minutes. While I was talking to him I overheard remarks made by his companions about the impertinence of sitting down at a table without a proper introduction. I knew I was in for it, but waited developments. Suddenly one of the men got up, placed himself right in front of me, clicked his heels together, and said, 'My name is von Eberstein' (the names are imaginary). I gave him my name in return. After a minute or two the second man got up: 'My name is Goldschmidt'. I gave him my name. When the third man got up I fortunately remem-

bered that I had a trump card to play, and after he had gone through his ritual I replied, 'My name is Dr. Schuster,' laying stress on the title. Whereupon all three silently left in a body. My degree was a sufficient distinction in rank to justify me in dispensing with the formality of asking for an introduction to them. I asked my friend what would have happened if I had not been a graduate; his reply was, that I should either have had to fight at least one duel or been treated as an outcast in German universities. All this happened fifty years ago, and must not be considered to apply to the present day.

IX. SIR GEORGE GABRIEL STOKES (1819-1903)

THE collection of Sir George Stokes's published papers and the *Memoir and Scientific Correspondence* edited by Sir Joseph Larmor together contain such an excellent account of Stokes's activities and personality that nothing remains but to confirm, illustrate, or emphasise what is already on record.

Stokes was elected as one of the secretaries of the Royal Society six years after the constitution of the Society had been altered by the limitation of the number of fellows elected annually. It was a critical time, and though there was no sudden change in the policy of the Society new traditions had to be established. The range of his knowledge, the width of his sympathies, and his almost infallible judgment peculiarly fitted Stokes for a position which offered

so many opportunities of advising striving and sometimes stumbling men, and guiding their work into profitable directions.

My own experience was similar to that of many others. In the account of Osborne Reynolds I have mentioned a certain experiment which I had performed, demonstrating that the motion of the radiometer was due to internal stresses. The paper describing the experiment was sent to the Royal Society and I received, in due course, a communication from Stokes forwarding some suggestions made by the referee. I complied to the best of my ability, and in informing me that the paper had been ordered to be printed, Stokes added that, in his judgment, the paper was not improved by the changes I had made in deference to the referee. He further made a significant remark, which is worth remembering by those charged with the difficult and responsible task of reporting on papers. It was to the effect that, in his opinion, it was best to allow the authors of papers to express what they had to say in their own words, even when improvements might be effected. When I quoted this remark to Maxwell a year or two later he told me that he had been the referee, but I believe he agreed with the general principle. The suggestions which Stokes himself so frequently made to the authors dealt with matters of principle rather than with the manner of expression.

I have in my possession five letters written by Stokes during March and April 1885, and dealing with a subject on which there has been, and still is, a good deal of misapprehension. The question at issue is referred to in the correspondence of July and

August 1899, reprinted in the *Memoir and Scientific Correspondence*, vol. ii, pp. 123-125.

Stokes writes to Rayleigh in July 1899:

'Some years ago Thomson or Kelvin (I forget which he was then), you, and I were together at the Royal Society, and Kelvin asked me what I thought of a result you had arrived at that the appearance of bands of interference in a spectrum did not prove regularity in the light, but only high definition in the spectroscope.

If this meant what it appeared to mean I utterly disbelieved it, it seemed so manifestly untrue.'

In his reply Rayleigh writes:

'I am afraid that I shall stand condemned, for I do think that "a vast succession of independent impulses following one another casually" would show interference, of course with the aid of a spectroscope.'

My correspondence with Stokes, which took place fourteen years earlier, deals with a design for an experimental arrangement suggested by him, which it was hoped would give 'a large retardation of one of two interfering streams of light relatively to the other, and yet having the bands in one part of the spectrum so broad as to be easily observed, unless that should be prevented by the irregularity of the vibrations of the incident light.'

The method depended on introducing into one of the interfering streams of light a dispersive medium, having a length adjusted so as to make the difference in path measured in wave-lengths in the two streams equal to each other within a certain range of the spectrum, in a manner suggested by that adopted in achromatizing lenses. I do not now remember what ultimately prevented the investigation from being carried out. When I examined the question some

years later (*Phil. Mag.*, June 1894¹) in the light of Gouy's and Rayleigh's discussion of the subject, I was fully converted to their opinion, but I do not believe that Stokes was ever convinced. In my judgment, the effect anticipated by Stokes in his arrangement would have been observed with sufficiently great resolving power, but it would have taught us nothing on the regularity of the incident light, because the observed regularity would have been introduced by the resolving power.

During my stay at Cambridge, many tales were current with regard to Stokes's taciturnity. My own experience is in the other direction. On several occasions I sat next to him at college dinners, but never had any difficulty in finding a subject of conversation on which he would enter with pleasure and sometimes with animation. He had several interesting tales of his intercourse with Brewster, who never could be made to abandon the corpuscular theory of light. Even when Foucault had proved that light was transmitted more slowly through water than through air, Brewster refused to give in.

Stokes was an old man when he died, but his scientific outlook always remained young. New ideas pleased him, and he delighted in hearing of experiments that did not fit in with any of the accepted theories. His peculiar form of wit is referred to in the *Memoir*, and I recollect one instance of it. At an excursion, during the celebration of the Kelvin Jubilee at Glasgow, Röntgen's discovery of the X-rays was referred to in the presence of some of the foreign delegates. Quincke stood up for the

¹*Phil. Mag.* [5], vol. xxxvii, p. 509.

claims of Lenard, whose work according to him had to some extent anticipated Röntgen. Stokes replied: 'Lenard may have had the rays in his brain but Röntgen got them into other people's bones'. Whenever I afterwards met Quincke he never failed to repeat this remark with enjoyment.

The strong religious opinions held by Stokes are well known. I am told, on trustworthy authority, that he voted against the extension of university privileges to nonconformists, but this should not be taken as an indication of any want of religious tolerance. His whole life would contradict such interpretation. He could only have acted under a strong sense of personal responsibility.

In the sketch of her father's life, Mrs. Laurence Humphry writes¹: 'As a little boy he was subject to violent though transient fits of rage . . .' I was interested in this remark, but not altogether surprised, because I once saw an almost ferocious look on Stokes's face. It was at a meeting of the British Association when he thought that someone was taking a liberty with him. But this look was quickly replaced by his usual smile, as he turned round and saw that it was only Lord Kelvin patting him on the back.

Stokes lived a long and useful life, alert and vigorous almost to the end. There are few men who have secured the esteem and love of their fellow-workers to the same extent. I shall always remember Lord Kelvin, as he stood at the open grave, almost overcome by his emotion, saying in a low voice: 'Stokes is gone and I shall never return to Cambridge again'.

¹*Memoir and Scientific Correspondence*, vol. i, p. 6.

X. HERMANN LUDWIG FERDINAND VON HELMHOLTZ (1821-1894), HEINRICH RUDOLPH HERTZ (1857-1894) AND WILHELM CONRAD VON RÖNTGEN (1845-1923)

THE names of Helmholtz and Hertz remain connected together in my mind, probably because when I met them towards the end of their lives, the conversation with both mainly turned on the nature of cathode rays. Hertz adhered to the idea that they consisted of vibrations, while Helmholtz from the beginning stood up for the corpuscular theory, and was rather sore that the idea did not originate in his own laboratory. During the few months I was working there, at the end of 1874, Goldstein was engaged in the important researches which the Royal Society has recognized by the award of the Hughes Medal. His experiments, which showed that the rays emanating from a cathode were strongly repelled by an adjacent parallel electrode, were sufficient to convince Helmholtz that the rays consisted of a projection of negatively electrified matter, but Goldstein did not fall in with this view. 'Of course,' said Helmholtz to me a few years later, 'as soon as Stokes became acquainted with Crookes's experiment he guided him into the right path.'

In his early years Helmholtz seems to have been very sensitive to criticism. Roscoe used to relate how he found him once in great distress, complaining that his whole scientific career was endangered because someone had thrown doubt on one of his conclusions.

The Physical Laboratory of Berlin in 1874 contained only three or four rooms, with about a dozen students engaged in researches on a number of subjects, mostly suggested by Helmholtz. In his daily rounds he used to discuss scientific problems freely with each in turn. He was as quick as Kelvin in being able to shift his mind quickly from one subject to another, but, in contrast with Kelvin, there was always a good deal of the *grand seigneur* in his attitude, and the title of *Excellency* bestowed upon him was borne with great dignity. He relaxed to some extent in his annual visits to Pontresina, where I received much encouragement from him in my early attempts to form some consistent theory of the passage of electricity through gases.

Her Excellency—his second wife, and a member of the South German aristocracy—was fond of society and gave weekly musical parties at their home in Berlin. She was of a highly strung and nervous temperament. During one of their visits to England they were staying with Roscoe at Manchester, and one morning she came down to breakfast complaining that she had been very ill during the night. She woke her husband, saying: 'Hermann, I am going to die'. 'That is easier said than done,' replied Helmholtz, turning round to sleep again. On one of his visits to Roscoe he was accompanied by his daughter. The conversation turned on the possibility of flying. 'It would be beautiful,' said Fräulein Helmholtz; 'one could escape so easily from one's chaperon; but then perhaps girls would be put into cages.'

The intimate relations which Helmholtz maintained with Kelvin are referred to in the biography published by Königsberger. I may quote here the passage from a letter written in 1864 by Helmholtz to his wife while on a visit to Lord Kelvin (William Thomson):

'The former (James Thomson) has a good brain with clever ideas, but he will not listen to anything except about engineering and talks about it at all hours, day or night, so that no other subject of conversation has a chance in his presence. It is amusing to watch each of the brothers (William and James) insisting on explaining something to the other, and neither of them listening to what the other says. But the engineer is more persevering, and generally gets his own way.

In the meantime I have seen a number of new and ingenious appliances and experiments of William Thomson's, and had two interesting days here in consequence. But Thomson's thoughts follow each other so rapidly that one can only obtain the necessary explanations about the working of his instruments, etc., by a series of questions to which it is difficult to get an answer. How his students can understand him is beyond me, as they cannot permit themselves to make the efforts to keep him to the point which I could venture upon. All the same, a number of students were working in the laboratory and seemed to know what they were doing. . . . Thomson's experiments did for my new hat. He set a heavy metallic disc, balanced on a point, into rapid rotation, and in order to show me how the disc became immovable by the spin, he struck it with a hammer. The disc revolted against this treatment and flew off to one side, projecting the iron stand in the opposite direction. The stand split my hat and carried it away. The disc happily did no damage beyond breaking some glasses.'¹

¹*Hermann von Helmholtz*, by Leo Königsberger, vol. ii, p. 5.

As is well known, the original suggestion that Hertz should undertake the experimental demonstration of the propagation of electrodynamic waves according to Maxwell's theory came from Helmholtz. The research could have been undertaken only by one who possessed exceptional abilities both on the theoretical and experimental side. The merit of the execution belongs to Hertz alone. 'Towards the end of 1888, he communicated his first decisive success in obtaining waves of comparatively short length, so that he could, by means of a parabolic mirror having an aperture of two metres, form a parallel beam and confirm previous results. Helmholtz wrote in answer: 'I was much pleased with your latest feat. It concerns things at the possibilities of which I have nibbled for years in the hope of finding a hole by which to enter. I am therefore familiar with your line of thought, and its great importance is quite clear to me.'¹ In the same year Hertz had the choice of accepting a professorship at Berlin or Bonn, vacancies having occurred through the deaths of Kirchhoff and Clausius. Hertz decided for Bonn, and Helmholtz, approving the choice, wrote: 'Whoever is still able to carry out extensive scientific work is well advised to keep away from large towns'. The great appreciation of Hertz's work by Helmholtz is shown by the unusual course he took in proposing the posthumous award of a certain prize to Hertz. He justified the proposal on the ground that it might 'discharge a debt of the nation, inasmuch as Hertz during his lifetime had been much less honoured by his countrymen than by other nations'.

¹ Königsberger, *loc. cit.*, vol. iii, p. 9.

In my own intercourse, I found Hertz to be a man of extreme modesty. During one of my visits to him, he received the news of some distinction bestowed upon him by the Academy of Sciences of Vienna. He seemed worried by it. 'Too many honours,' he said, 'are as bad as too few. They do not add to the pleasure and only create jealousies.' With regard to the fundamental question of cathode rays, he attached great importance to an experiment he had made, which showed that they could pass through gold leaf, and looked upon this as telling in favour of waves, to which I could not agree.

I am told that in early youth Hertz gave expression to weird ideas with regard to possible happenings if some of the ordinary circumstances of life were changed.

It is sad to think that the illness which led to his death was probably aggravated, if not caused, by the insanitary state of his laboratory, which, I was told, had been built and used as a hospital for certain contagious diseases.

The succession of experimental discoveries leading, through Hertz, to the important researches first of Lenard and then of Röntgen is well known. I never spoke to Röntgen but, hearing of his presence in another hotel during one of my visits to Pontresina, I called on him. He was not at home, but I saw his wife, who received me in a friendly manner. The call was never returned, though amends for this want of courtesy were made a few months later.

Returning to Manchester from a short Christmas holiday at the beginning of the following year (1896), I called at my laboratory on my way home

from the station. On looking at the accumulated correspondence I opened a flat envelope containing photographs which, without explanation, were unintelligible. Among them was one showing the outlines of a hand, with its bones clearly marked inside. I looked for a letter which might give the name of the sender and explain the photograph. There was none; but inside an insignificant wrapper I found a thin pamphlet bearing the title, *Ueber eine neue Art von Strahlen*, by W. C. Röntgen. This was the first authentic news that reached England of the discovery of the so-called X-rays. I sent a translation of the paper to *Nature*, where it appeared on the 23rd January 1896.¹

XI. HENRY WILDE (1833-1919)

HENRY WILDE would have taken a very prominent place among the scientific men of his time had his exceptional abilities not been handicapped by an obstinate and quarrelsome disposition. He had imagination, ingenuity, and considerable experimental skill, but on the other hand he was possessed by vanity, pugnacity, and contempt for anybody else's opinion. In his scientific work he had a good sense of discrimination between the essential and the accidental, but in his personal relations with others trivial grievances were magnified into serious injuries. Once he complained to the Vice-Chancellor of the University of Manchester that one of his clerks had insulted him. After an expression of regret and a request for details, it appeared that the clerk, by

¹*Nature*, vol. liii, p. 274.

an oversight, had omitted to put 'F.R.S.' after his name on an envelope.

The threat of legal proceedings was Wilde's favourite method of controversy, and he was reported to have offered his solicitors twice the usual fees on condition that they should never dissuade him from taking legal action. I once asked him why he was so fond of going to law. He replied that it was out of gratitude; and explained that early in his career, when he was the defendant in a lawsuit, the judge put a question to him which he could not answer, but while he was thinking about the matter on his way home, he was led to the train of thought which resulted in the construction of the first dynamo-electric machine. One would like to know the name of the judge and the exact nature of the question. The lawsuit referred to was probably that brought by the Universal Private Telegraph Company against Wilde for infringement of patent; the case was decided in his favour.

During the greater part of his scientific life, Wilde was afflicted by a sense of injury, due to what he looked upon as an insufficient recognition of his claim to have invented the dynamo-electric machine. This culminated ultimately in an unfortunate lawsuit, which Wilde brought against Silvanus P. Thompson, who in his well-known treatise on *Dynamo-Electric Machinery* had stated that Werner Siemens, in a communication read before the Berlin Academy of Sciences on the 17th January 1867, first used the expression to designate all appliances which now pass under the collective name of 'dynamos'.¹

¹*Monatsbericht der königl. preussischen Akademie der Wissenschaften* for January 1867, p. 55. Siemens uses the term '*elektro-dynamisch*'.

Wilde, on the other hand, claimed that the term was first applied to his own machine by Brooke. Thompson was certainly inaccurate in his statement. In the only sentence in which the expression 'dynamo-electric' was used by Siemens, it denotes what we now should call 'motors'. It is a pleasure to add that, while Silvanus Thompson won his case both in the first instance and on appeal, he afterwards revised the historical account given in his treatise and recognized Wilde's work in a manner that is not only adequate but even generous.

Disregarding questions of nomenclature, there is no doubt that Wilde's paper, communicated to the Royal Society by Faraday in 1866,¹ was the first important step in the production of electric currents on a scale which opened out the possibility of great industrial applications. Stokes more than once referred in conversation to the great impression created at the meeting of the Royal Society when an iron wire, fifteen inches long and one-quarter of an inch in diameter, was raised to white heat and melted.

Prof. W. W. Haldane Gee, of the University of Manchester, in his obituary notice of Henry Wilde (*Memoirs of the Manchester Lit. and Phil. Soc.*, vol. 63, No. 5), which contains much interesting information, tells us that Wilde was the son of a working man and was apprenticed to an engineering firm at the age of sixteen. Whatever the social status of his parents may have been, his early surroundings must have been refined and cultured. Though self-taught,

¹"Experimental Researches on Magnetism and Electricity", Part I., *Proc. Roy. Soc.*, vol. xv, p. 107.

his language and style of writing were those of a highly educated man. The extent of his knowledge of the history of science and philosophy and his acquaintance with general literature were remarkable.

Wilde's contributions to technical science were both numerous and important, but in his later years practical applications interested him mainly in a financial sense.

It will be remembered that when the general public was brought to realize, almost suddenly, that the electric lighting of houses would come into general use, a panic set in among the shareholders of gas companies. Wilde, with clear foresight, chose the moment when the shares were at their lowest, sold his electric works and invested the proceeds in the shares of a leading gas company. This, together with the royalties he received, secured him a substantial income, and he could thenceforward devote himself to unremunerative work.

Apart from the subject of terrestrial magnetism, to which he devoted much time, and that of aviation, Wilde concentrated his attention in later years mainly on questions of a fundamental character. In these, his self-trained mind felt itself free to disregard all authority and to be guided only by his own instincts. Facts were, to him, simply illustrations to be accepted or rejected according as they did or did not fit in with his own views. His firm belief in the evidence of an intelligent design in Nature, which was the basis of his religious and scientific faith, convinced him of the necessary simplicity not only of fundamental laws but also of fundamental facts. Hence his absolute rejection of

anything but integer numbers to express physical or chemical relationships. If chemists gave fractional figures for their atomic weights, their measurements, in Wilde's judgment, were necessarily wrong, and if simplicity rules the world, atomic weights were likely to follow the same order as planetary distances, with regard to which he gave unqualified assent to Bode's Law.

For the subject of the annual 'Wilde Lecture' of the Manchester Literary and Philosophical Society, which he had endowed and himself delivered in 1902, Wilde selected the old-standing controversy between the followers of Newton and Leibnitz on the measurement of force.¹ To him force meant energy, and he naturally put himself on the side of Leibnitz. The lecture, to which he gave the title, 'On the Evolution of the Mental Faculties in Relation to some Fundamental Principles of Motion', was a great effort of special pleading, and contains references to passages in the writings of Bacon, Locke, Halley, Copernicus, De Morgan, Descartes, Newton, MacLaurin, Schopenhauer, and more modern writers. As an example of Wilde's style, the second paragraph of the lecture may be quoted:

'It will be universally allowed that if one of the Simiidæ could be taught to enunciate a false proposition, *e.g.* that space is four dimensional, or that the twentieth century commenced on January 1st, 1900, such a creature would be much more interesting to naturalists, and be more highly valued by collectors, than any of its inarticulate companions of the forest.'

Wilde had a grim sense of humour. When some

¹*Manchester Memoirs*, vol. xlv, no. 10, pp. 1-36.

act of the University of Manchester displeased him, one could feel pretty sure that he would give effect to his displeasure by a benefaction to some other scientific institution, generally in Oxford or Paris. He once asked the treasurer and an important member of the council of Owens College to call on him on an important matter. Hopes of a substantial endowment ran high, but they had to hide their disappointment when they found that their presence was only wanted to witness a signature or to assist at some similar trivial function.

Wilde's residence stood near the top of a steep lane on Alderley Edge. When bicycling came into fashion several accidents occurred at that point, and Wilde fixed on the usual danger-post a board which carried, beneath the drawing of a skull and cross-bones, the legend: 'A stretcher may be obtained at the Hurst Cottage below when required'. A picture of the post, in its surroundings and with two cyclists inspecting it, appeared in the *Daily Graphic* on the 11th September 1900.

Wilde received blows as cheerfully as he dealt them. It was once my disagreeable task to propose a vote of censure on him while he was sitting in the presidential chair at the Literary and Philosophical Society of Manchester. He had written a letter making unjustifiable accusations against the treasurer of the Society, and some action became necessary. I first gave him an opportunity of withdrawing the letter, but he refused, and when I had made my speech and it came to the vote, Wilde simply said, 'I withdraw the letter,' and went on with the business of the meeting. 'I have had many pin-

pricks from you, but you have also done me some kind actions,' was all the reference he made to the incident after the meeting. Our friendship was never affected by such incidents. He might, at the end of a long discussion during one of his frequent visits to my laboratory, tell me that I was not fit to be a university professor, and a day or two later make amends by sending me a basket of beautiful hot-house grapes.

Wilde's fondness for litigation has already been mentioned. One might almost say that he looked upon it as a form of recreation. I have before me copies of lawyer's letters filling nearly twenty pages, all containing threats of legal action against the Manchester Literary and Philosophical Society, which he truly loved and of which he was a munificent benefactor. It is not necessary to enter into details with regard to them, but his dispute with the Royal Society of Arts deserves to be placed on record, and as an introduction to it I must refer to a previous incident.

Wilde had given a sum of money to the Manchester Society to enable it to award from time to time a gold medal for meritorious work. The Society considered it appropriate to offer the first medal to the donor. Knowing his sensitiveness with regard to the discovery of the dynamo machines, they laid great stress on it in formulating the reasons for the award. Wilde was up in arms: 'Your Society,' he told the Council, 'is a body for the prosecution of pure science. You have nothing to do with technical applications.' He refused to accept the medal unless the Council modified their reasons for the award,

emphasising his discoveries in pure science. The Council did not see its way to accept Wilde's own formula and the matter proceeded no further. In the following year (1900), the Council of the Royal Society of Arts decided to confer the Albert Medal on Wilde 'for the discovery and practical demonstration of the indefinite increase of the magnetic and electric forces from quantities indefinitely small'. Wilde again raised objections. The Royal Society of Arts, unlike the Manchester Society, was concerned with industrial applications, while the wording of their award laid stress on a principle rather than on an application. This aroused his suspicion that his claim to the invention of the dynamo and its application to industrial processes was not sufficiently recognized by the Society. In his reply to the letter conveying the award of the medal, Wilde wrote:

'Considering that the principal object of the Society is to give encouragement to Arts, Manufactures, and Commerce, which object is prominently set forth in most of the awards of the Albert Medal hitherto made, the absence of all reference to the industrial applications of my discoveries and inventions in the terms of the award is a notable omission, and, if unrectified, will effectually preclude me from accepting the honour for which I have been designated by the Council.

Three days later Wilde wrote again to suggest a wording which he would consider satisfactory. In the meantime the proposed conferment of the medal in the original terms had been published in the daily press; this resulted in a lawyer's letter, and the issue of a writ to restrain the Society of Arts from announcing the award in their own journal before some

agreement had been arrived at as to the wording. The Society then altered the wording. It added a sentence referring to Wilde's application of his machine to search-lights and the electro-deposition of metals; and with regard to the dynamo machine, it added that the principle which formed the basis of Wilde's work was 'now used in all dynamo machines'. This was a fair and adequate statement, but it displeased Wilde more than ever. I think, however—and I saw much of him at that time—that he was more amused than vexed when the Society sent him the medal by post instead of following their usual practice of presenting it at their annual meeting under the presidency of the Prince of Wales.

The incident ended with a letter addressed by Wilde to the Institution of Electrical Engineers, in which, after declaring his dissatisfaction with the terms under which the medal had been bestowed upon him by the Royal Society of Arts, he proceeds:

'Nevertheless, the action of the Society has invested the Albert Medal of 1900 with a considerable degree of historical interest, and, in response to the recent invitation of the Council of the Institution for gifts of such objects to form a permanent Museum, I enclose herewith the Medal as a contribution to the collection.'

The whole correspondence was afterwards published and freely circulated by Wilde.

One of Wilde's peculiarities was his strong objection to having his photograph taken, which was a pity, because he really had a fine and expressive face. 'I want to be remembered by my works and not by my physiognomy,' he often told me. He added that on one occasion he gave way to the wishes of his wife,

but having repented he had the plate destroyed. A copy, however, seems to have been kept by the photographer and was reproduced in his obituary notice. I cannot help regretting this disregard of his wishes.

It remains to mention his extensive benefactions. He gave altogether £10,000 to the Manchester Literary and Philosophical Society and £5500 to the Académie des Sciences of Paris. His endowments, during his life, of a readership, lectureships and a scholarship at Oxford amounted to over £17,000, and a contribution of £1500 to the Benevolent Fund of the Institution of Electrical Engineers raised the total of these gifts to over £34,000. Yet he died a comparatively poor man. The residuary estate, which was bequeathed to the University of Oxford, after deducting some minor legacies, only amounted to £10,000.

I am afraid that this account dwells a good deal on Wilde's pugnacious peculiarities, but in spite of many acute differences of opinion, I had a very high regard for his straightforward character and attainments. We always remained friends.

XII. ESMATT EFFENDI

I AM not aware that any publication of Esmatt Effendi has ever seen the light of day, but nevertheless my readers, I hope, will agree that his name deserves to be included in this collection of reminiscences. He certainly possessed two essential qualities, enthusiasm and perseverance. I made his

acquaintance at Suez, on the evening of the 3rd May 1882, when, on behalf of the Khedive of Egypt, he received a party sent out under the auspices of the Royal Society to observe the total eclipse of the sun that was to take place on the 17th May at Sohag, some way up the Nile. He gave us a very promising account of the local facilities, more especially with regard to bricks and mortar for the foundations on which to place our telescopes; and if his predictions did not come true, and the only brick we saw was that aimed at the head of one of the party by an inhabitant of the village, his intentions were undoubtedly good.

Esmatt Effendi had an ambition to learn something about astronomy and showed great interest in a sextant that I had taken out to check our chronometers. He begged me to teach him its use. After a few lessons, I found him one day trying to find the image of the sun in an artificial horizon, having pushed all dark glasses out of the way. I had warned him against this, and got rather angry with him. He replied, 'I am an Egyptian, and I cannot see the sun with the dark glasses. When an Egyptian says he is going to do something he is going to do it, and I am going to see the sun through this sextant even if I lose my eyesight.' I had to lock up the sextant.

It was some years before I heard of Esmatt again. Through diplomatic influence, the Naval Observatory at Washington had been persuaded to take him in as a kind of apprentice. They found him, as I had done, persevering and enthusiastic, but incapable of assimilating any knowledge. They tried to persuade him to return home and take up some other occupa-

tion, but Esmatt Effendi had made up his mind to stay. The authorities of the Observatory learned afterwards that all the time he was half-starved, and had had to sell his books and a great part of his clothing to pay for his board and lodging. Matters ultimately reached a crisis and he was told to leave. He finally consented, on condition that the authorities would give him a testimonial which would enable him to find a position at home. They considered the matter, and ultimately resolved that it was worth while to stretch a point, and they sent him the requested testimonial. To their surprise, they found Esmatt again at his desk next morning. He was reminded that they had kept their part of the bargain and that he must keep his. Esmatt stood up, took the testimonial out of his pocket, waved it in front of their faces, and said, 'The man who deserves this testimonial deserves to work in the Observatory of Washington'. The rest of this story, which I give on the authority of one of the principal astronomers concerned, must be left to the imagination.

CONCLUSION

It is with some hesitation that I conclude these reminiscences with the account of an incident that revives painful recollections, and the publication of which I should, for obvious reasons, have preferred to be left over until after my death. It concerns a distinguished personality whose memory is cherished by many friends, but their ranks are now rapidly

thinning, and for this reason I feel compelled to disregard personal considerations.

Early on during the War, I was one morning surprised to find paragraphs in the daily press stating that a wireless apparatus had been found and 'seized' in my house, with more or less veiled references to the purpose for which the apparatus was likely to have been erected. The complete story may be told some day; at present it is sufficient to say that I do not blame the newspapers.

Though I knew that the implied accusation was not likely to impress my friends, the matter, in view of my position at the time, was serious, and it was with fear and trembling that I entered the Athenæum a few days later and selected a solitary place in the coffee-room. I was leaving again directly after luncheon, and as I was putting on my coat in the hall I suddenly felt someone stepping up behind to help me. Surprised at this politeness, which is somewhat unusual in the Club, I turned round and looked into the kindly face of Lord Roberts, with whom I had no personal acquaintance. The hall was then full of members of the Club, and it was obvious that the action was intended to be, and in fact was, a demonstration. Such incidents are not likely to be forgotten.

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